FINAL
Osborne Pond Feasibility Study (FS)
Former Camp Edwards, Massachusetts

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ABBREVIATIONS AND ACRONYMS

ANGB	Air National Guard Base
ARAR	Applicable or Relevant and Appropriate Requirements
ASP	Ammunition Supply Point
BIP	Blown-in-Place
CAA	Clean Air Act
CD	Cultural Debris
CDC	Contained Detonation Chamber
CENAE	United States Army Corps of Engineers, New England District
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CMR	Code of Massachusetts Regulations
DGM	Digital Geophysical Mapping
DGPS	Differential Global Positioning System
DMM	Discarded Military Munitions
DoD	Department of Defense
EC	Engineering control
EE/CA	Engineering Evaluation/Cost Analysis
EOD	Explosive Ordnance Disposal
EPO	Environmental Protection Office
EMI	Electromagnetic Induction
EWI	Explosive Waste Incinerator
FDEMI	Frequency-Domain Electromagnetic Induction
FS	Feasibility Study
FUDS	Formerly Used Defense Sites
HAZWOPER	Hazardous Waste Operations and Emergency Response
HRR	Historical Records Review
HTRW	Hazardous, Toxic, or Radioactive Waste
IAGWSP	Impact Area Groundwater Study Program
IC	Institutional Control
IR	Infrared
IRP	Installation Restoration Program
M&D	Mag and Dig
M.G.L.	Massachusetts General Law
MAARNG	Massachusetts Army National Guard
MassDEP	Massachusetts Department of Environmental Protection
MC	Munitions Constituents
MCP	Massachusetts Contingency Plan
MD	Munitions Debris
MEC	Munitions and Explosives of Concern
MMCL	Massachusetts Maximum Contaminant Levels
MMR	Massachusetts Military Reservation

ABBREVIATIONS AND ACRONYMS (Cont.)

MPM	Most Probable Munition
MRS	Munitions Response Site
MSD	Minimum Separation Distance
NA	Not Applicable
NCP	National Contingency Plan
NEW	Net Explosives Weight
NOx	Nitrates
NPDES	National Pollutant Discharge Elimination System
O&M	Operation and Maintenance
OB/OD	Open Burn/Open Detonation
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
PPE	Personal Protective Equipment
PRG	Preliminary Remediation Goal
QA	Quality Assurance
QC	Quality Control
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RSP	Render Safe Procedures
RTS	Robotic Total Station
SAM	Sub Audio Magnetics
SAR	Synthetic Aperture Radar
SVOC	Semi-Volatile Organic Compounds
TDEMI	Time-Domain Electromagnetic Induction
TMV	Toxicity, Mobility, or Volume
TPP	Technical Project Planning
U.S.C.	United States Code
USACE	United States Army Corps of Engineers
USAESCH	United States Army Engineering and Support Center, Huntsville
USCG	United States Coast Guard
USEPA	United States Environmental Protection Agency
UXO	Unexploded Ordnance
VOC	Volatile Organic Compound
WAA	Wide Area Assessment

EXECUTIVE SUMMARY

This Feasibility Study (FS) was prepared by ECC to identify and evaluate cleanup alternatives for Osborne Pond and the associated upland area (the Site) at the Massachusetts Military Reservation (MMR) in Bourne, Massachusetts. This report is being prepared for the United States Army Engineering and Support Center, Huntsville (USAESCH) and the United States Army Corps of Engineers (USACE), New England District (CENAE). The work has been conducted pursuant to the Formerly Used Defense Site (FUDS) Program (USACE ER 200-3-1) under FUDS Project No. D01MA000913.

The FUDS Program conducts response actions at properties formerly owned, leased, possessed, or used by the military services. The Army is the Department of Defense executive agent for FUDS, and the USACE is responsible for carrying out the program. Cleanup is performed in consultation with the U.S. Environmental Protection Agency (USEPA) and state environmental and health offices, and in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended and the National Oil and Hazardous Substances Contingency Plan (NCP).

The purpose of this FS is to facilitate the evaluation of remedial alternatives to reduce, eliminate, or control actual or potential human-health and ecological risks. This FS does not select a preferred alternative, but describes the alternatives under consideration. The preferred alternative will be identified in the Proposed Plan and, after a public comment period has been conducted, a final remedy selection will be described in a Decision Document.

Osborne Pond is a naturally occurring feature, approximately 8.5 acres in size. The pond is located within the United States Coast Guard (USCG) housing area, just west of the airfield, in the southern portion of MMR. The Site includes Osborne Pond and the adjoining Former Bivouac Area located to the west and southwest of Osborne Pond. Osborne Pond and adjoining land are considered a recreational area. Fishing, canoeing, swimming, and other motor boating are not permitted at this time. Signs posted along the perimeter of Osborne Pond indicate that swimming and boating are not permitted. Aerial photographs from 1995 indicate that about 80 percent of the pond is buffered by at least 100 feet of tree cover/heavy vegetation and about 50 percent of that land has a 10 to 50-foot shore width to the tree line. The unoccupied Stone School is located approximately 450 feet to the southwest of the pond. There is no septic drainage into Osborne Pond. Nine storm drain outfall lines drain into the pond. A 1947 aerial photograph of the area depicts a road from a former ammunition supply point (ASP) to Osborne Pond.

The Site was not a known disposal/dump area for munitions; however, an interview with a former Air Force Reserves explosive ordnance disposal (EOD) technician, otherwise known as “Witness 32,” stationed at MMR from 1963 through 1973 indicated that a munitions disposal area was possibly located in Osborne Pond (see Appendix B). Witness 32 reported that during a drought in 1967 or 1968, the drop in the water level of the pond exposed mortars, grenades and artillery rounds. He said that EOD recovered some of these rounds, but he was not sure that everything was recovered. He also noted that he did not physically see the munitions, but was aware of the fact through a picture of the pond and the munitions that appeared on the front page of the weekly Base newspaper, “Otis Notice”. Efforts to obtain this edition of the Otis Notice during the investigation were unsuccessful.

Digital geophysical mapping of the Osborne Pond water body was conducted between August 9, 2003 and August 11, 2003 (USAESCH, 2003). The objective of the mapping effort was to locate magnetic anomalies associated with munitions and explosives of concern (MEC) on or buried beneath the pond bottom. MEC items are military munitions that may pose unique explosive risks, including: (a) unexploded ordnance (UXO); (b) discarded military munitions (DMM); or (c) munitions constituents (MC) (e.g., trinitrotoluene), present in high enough concentrations to pose an explosive hazard. DMM are military munitions that are unfired and have been abandoned without proper disposal or have been removed from storage in a military magazine or other storage area for the purpose of disposal. DMM items are still capable of functioning.

An Engineering Evaluation/Cost Analysis (EE/CA), which included performing intrusive investigations and environmental sampling, was performed in 2005-2006 at the Site. As part of the EE/CA, digital geophysical mapping (DGM) of the upland area adjacent to the Osborne Pond water body was conducted in 2005 using a digital magnetometer system for data collection. The objective of the project was to locate magnetic anomalies associated with MEC on the surface or buried beneath the ground surface, within the Former Bivouac Area adjacent to the pond. The Former Bivouac Area is comprised of 14 acres, 10.5 of which are undeveloped and were selected for investigation (the area, equaling approximately 3.5 acres, surrounding Stone School was excluded as it has been re-graded since closure of the former bivouac area). Geophysical mapping was conducted on single-line (3-foot wide) transects oriented east-west and placed approximately 15 meters apart, with additional transects where roads had been depicted on the historic aerial photos. Additionally, eleven locations were selected at apparent pedestrian access points around the perimeter of the Osborne Pond water body for geophysical survey. A total of 1.34 acres, or 12.7 percent, of the 10.5 acres was surveyed.

In 2006, a total of 807 land-based magnetic anomalies identified during the survey were intrusively investigated (Zapata, 2007). The single MEC item discovered during intrusive investigation, an unfired high explosive anti-tank rocket (2.36-inch M6 series) with the ogive and fins rusted off and the cone laying outside the body, was a DMM item found at a depth of two inches below ground surface approximately 65 feet from the edge of Osborne Pond. The DMM item found was turned over to the CENAE MMR UXO Safety Specialist on June 06, 2006 for disposal. The other 806 targets selected for investigation included assorted pieces of cultural debris (CD) consisting of nails, soda cans, ball bearings, steel rope, rebar, fence posts, discarded hand tools, fence wire, and various other ferrous items unrelated to military munitions.

Soil samples were collected adjacent to the single DMM item identified during the 2006 intrusive investigation in order to test for the possible presence of MC related to the DMM item filler. Results of the analyses indicated the presence of the following explosives constituents immediately adjacent to and beneath the DMM item: 2,4,6-Trinitrotoluene, 2-Amino-4, 6-Dinitrotoluene, and 4-Amino-2,6-Dinitrotoluene. None of the soil samples contained concentrations of explosives constituents above applicable Massachusetts Contingency Plan (MCP) soil standards or USEPA Region 9 Preliminary Remediation Goals (PRG) (HTTP://WWW.EPA.GOV/REGION9/SUPERFUND/PRG/ FILES/04USERSGUIDE.PDF).

The EE/CA (Zapata, 2007) indicated the use of Institutional Controls (IC) as the recommended alternative for the upland area. The EE/CA recommended "posting of warning signs and distribution of informational pamphlets to area residents, workers, and students". In addition, it recommended "a Recurring Review be carried out every five years to assess the continued effectiveness of the periodic munitions and explosives of concern response activities" (Zapata, 2007). It should be noted that neither the Massachusetts Department of Environmental Protection (MassDEP) nor the USEPA concurred with this decision, citing the need for additional investigation in the upland area.

A Remedial Investigation (RI) was conducted from July 8, 2008 to July 14, 2008. As part of this effort, previously gathered geophysical data provided by USAESCH was used to reacquire and investigate 17 selected targets and five outfall areas within Osborne Pond. MEC items and/or munitions debris (MD) were not discovered within the pond during the intrusive field investigations. MD are remnants of munitions (e.g., fragments, penetrators, projectiles, shell casings, links, and fins) remaining after munitions use, demilitarization, or disposal. Sediment samples were to be collected if MEC or DMM items or MD were discovered during the geophysical investigation within the pond. Since no items were discovered, sediment samples were not collected.

As part of the RI, surface water samples were collected at three locations within the pond to demonstrate that there were no environmental impacts to the pond as a result of past activities. The results for SVOC, explosives compounds, and perchlorate were non-detect in all samples. Only a few trace metal analytes were detected in the samples.

Based on the archival data, historical and aerial photographs, documents, and previously conducted site investigations, the RI concluded that the Site was not known as a munitions disposal area and/or as a range, additional investigations are not warranted, and there have been no adverse effects to the upland or pond areas.

The goal of a remedial action is to reduce explosives safety hazards and contaminants of concern to ensure protection of human health, public safety, and the environment. Contaminants of concern have not been detected at elevated concentrations in the media at the Site, so remedial actions were not focused on reducing concentrations of contaminants of concern. Explosives contaminants were identified in soil beneath the DMM item found at the Site; however none of the contaminant concentrations exceeded State or Federal clean-up standards. Also, since the only type of MEC found at the Site was DMM, the remedial action objectives (RAO) were focused on significantly reducing the risk of direct contact with potential DMM by human receptors conducting surface recreational activities. Based on the results of the RI Report (ECC, 2010) and consistent with the EE/CA (Zapata, 2007), it is the opinion of the USACE that the area to be considered for further action is the Osborne Pond water body and approximately 14 acres of land located to the west and southwest of Osborne Pond that was a Former Bivouac Area .

The RAOs guide the development of alternatives and focus the comparison of acceptable remedial action alternatives, if warranted. Access to the MMR and the Osborne Pond Site is controlled by manned security gates, which prevent access to the Site by the general public. The Osborne Pond Site is located adjacent to the USCG housing area and is currently considered a recreational area. Fishing, canoeing, swimming, and other motor boating are not permitted at this time. Signs posted along the perimeter of Osborne Pond indicate that swimming and boating are not permitted. The future use of the property is expected to continue to be recreational. Likely receptors include adults who work on the MMR or adults and children that live in military housing on the MMR.

The RAO for DMM at the Site is to:

- Significantly reduce the risk of direct contact with potential DMM by human receptors conducting surface recreational activities.

General response actions are those actions that will achieve the RAO. The following general response actions were considered for the Site:

- **No Action** – The No Action alternative is evaluated to satisfy the NCP requirement of 40 CFR 300.430(e)(6), which requires consideration of this alternative as a baseline against which other alternatives may be compared.
- **Public Education** – Public education utilizes a Public Education Program to provide risk management through education of the local populace, specifically residents who may be exposed to a potential hazard. Some DMM may always remain at the site; thus, Public Education is included as a component of all remedial alternatives. Public Education is considered a “limited” action alternative by the USEPA (USEPA, 1988).
- **Removal** – DMM can be detected, recovered, and disposed from the ground surface and/or below the ground surface. Alternatives for removal include technologies for detection, recovery, and disposal.

Upon completion of the identification and screening of technologies for DMM detection, recovery, and disposal the following remedial alternatives were developed:

- Alternative 1 – No Action;
- Alternative 2 – Public Education;

- Alternative 3 – Limited Subsurface Clearance of Recreational Areas with Public Education;
- Alternative 4 – Subsurface Clearance of Recreational Areas with Public Education; and
- Alternative 5 – Complete Clearance of the Former Bivouac Area with Public Education.

Remedial alternatives were assessed in a detailed evaluation against the evaluation criteria described in the NCP, Section 300.430. The evaluation criteria include:

1. Overall Protection of Human Health and the Environment;
2. Compliance with Applicable or Relevant and Appropriate Requirements (ARARs);
3. Long-Term Effectiveness and Permanence;
4. Reduction of Toxicity, Mobility, or Volume (TMV) of Contaminants through Treatment;
5. Short-Term Effectiveness;
6. Implementability;
7. Cost;
8. Regulatory Agency acceptance; and
9. Community Acceptance.

Regulatory agency acceptance and community acceptance will be addressed in the future based on comments on the FS and the Proposed Plan.

Based on the detailed analysis of remedial alternatives, the strengths and weaknesses of the remedial alternatives relative to one another were evaluated with respect to each of the NCP criteria. This comparison is presented below.

COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

Alternative		Overall Protectiveness of Human Health and the Environment	Compliance with ARARs and To Be Considered Criteria	Long-Term Effectiveness and Permanence	Reduction of TMV of Contaminants Through Treatment	Short-Term Effectiveness	Implementability	Cost
1	No Action	Not Protective	Not Applicable	Potential risks remain. RAOs not achieved.	No reduction	No impact to community or site workers since no action will be taken.	Most implementable	$0
2	Public Education	Protective	Compliant	Potential risks may remain but are mitigated by the Public Education Program. RAOs may not be achieved.	No reduction	No impact to community or site workers.	Easily implementable	$397,000

3	Limited Subsurface Clearance of Recreational Areas with Public Education	Protective	Compliant	Potential risks may be reduced by surface removal and mitigated by the Public Education Program. RAOs will likely be achieved.	Reduction, if DMM are present	Significant impact on site workers. Limited impact on community. Impact on the environment due to clearing and vegetation removal.	Implementable	$644,000
4	Subsurface Clearance of Recreational Areas with Public Education	Protective	Compliant	Potential risks may be reduced by subsurface removal and mitigated by Public Education. RAOs will be achieved.	Reduction, if DMM are present at surface and subsurface	Significant impact on site workers. Limited impact on community. Impact on the environment due to clearing and vegetation removal.	Implementable	$962,000
5	Complete Clearance of the Former Bivouac Area with Public Education	Protective	Compliant	Potential risks may be eliminated by subsurface removal and mitigated by Public Education. RAOs will be achieved.	Reduction, if DMM are present at surface and subsurface	Significant impact on site workers. Limited impact on community. Impact on the environment due to clearing and vegetation removal.	Implementable	$2,045,000

Notes:

ARARs	Applicable or Relevant and Appropriate Requirements
RAOs	Remedial Action Objectives
TMV	Toxicity, Mobility, or Volume
DMM	Discarded Military Munitions

1. INTRODUCTION

This Feasibility Study (FS) was prepared by ECC to identify and evaluate cleanup alternatives for the Osborne Pond water body and the associated upland area (the Site) at the Massachusetts Military Reservation (MMR) in Bourne, Massachusetts. This report is being prepared for the United States Army Engineering and Support Center, Huntsville (USAESCH) and the United States Army Corps of Engineers (USACE), New England District (CENAE). The work has been conducted pursuant to the Formerly Used Defense Site (FUDS) Program (USACE ER 200-3-1) under FUDS Project No. D01MA000913.

1.1 PURPOSE

The purpose of this FS is to facilitate the evaluation of remedial alternatives to reduce, eliminate, or control actual or potential human-health and ecological risks. This FS does not select a preferred alternative, but describes the alternatives under consideration. The preferred alternative will be identified in the Proposed Plan and a final remedy selection will be described in a Decision Document.

1.2 SITE DESCRIPTION

This section presents site information including location, topography, climate, surface water and hydrology, and natural resources.

1.2.1 Site Location

The Osborne Pond water body is a naturally occurring feature, approximately 8.5 acres in size, situated in the cantonment area of MMR (Figure 1-1). The pond is located within the United States Coast Guard (USCG) housing area, just west of the airfield, in the southern portion of MMR. The Site includes 8.5 acres that make up the Osborne Pond and approximately 14 acres of land located to the west and southwest of Osborne Pond that was a Former Bivouac Area . The pond and adjoining land are considered a recreational area, excluding swimming and boating in the pond. The address of record is Buzzards Bay, Massachusetts; however, according to town boundary maps, the Site is within Bourne's town limits (WWW.MMR.ORG).

1.2.2 Topography

The central, southern, and eastern portions of MMR are generally flat, with elevations rising to the north and west to between 60 and 200 feet above sea level. The terrain in the northern and western portions of MMR is mainly hilly, with some steep-sided hills, depressions, and valleys. Elevations in those areas range from 200 to 300 feet above sea level. Pine Hill, the highest point on MMR, has an elevation of 306 feet above sea level (Tetra Tech, 2003).

Osborne Pond is a kettle pond formed by regional glaciation. Adjacent land slopes toward the pond at a slope of as much as 25 percent to the southwest and as little as 5 percent to the west; the average slope is about 15 percent. Almost 500 feet to the south is the similarly sized Edmonds Pond. The ponds are separated vertically by approximately 15 feet.

1.2.3 Climate

Falmouth, Massachusetts, which is adjacent to Bourne, receives an average of 43.9 inches of rain and melted snow each year (WWW.FALMOUTHCHAMBER.COM). The maximum temperature for this area is usually reached in August, with an average high temperature of 77 degrees Fahrenheit. The minimum average temperature is usually reached in January, when the average temperature falls to 23 degrees Fahrenheit.

1.2.4 Surface Water and Hydrology

There are no major rivers or streams within the boundaries of MMR because rainfall rapidly infiltrates the sandy subsurface materials that cover the majority of the reservation. However, intermittent streams are present during moderate or heavy rainfall, and some areas are underlain by less permeable substrate. Any rainfall runoff which is not absorbed into the ground collects in depressions and kettle holes, where it percolates to groundwater or evaporates. Several small freshwater kettle ponds (such as Osborne Pond), typically covering less than 10 acres, are found within the boundaries of MMR.

A single groundwater flow system, known as the Cape Cod Aquifer, underlies all of MMR. The specific portion of the Cape Cod Aquifer that underlies MMR is known as the Sagamore Lens. The total thickness of the aquifer underlying MMR varies from approximately 80 feet in the south to approximately 350 feet in the north. The top 90 to 140 feet of the aquifer are made up of well-sorted, brown, and medium to very coarse sand with some gravel. Underlying those deposits are finer-grained sand, silt, and clay. The entire aquifer overlies crystalline bedrock. The elevation of the groundwater table varies from a high of 60 feet above sea level in the MMR impact area to a low of 45 feet above sea level along the southern boundary of MMR. Groundwater flow of approximately 1 to 3 feet per day is generally radially outward from the variable high point in the water table, located generally under the J Ranges, at the MMR's eastern boundary, just north of Snake Pond. Typical yields from the aquifer can exceed 1,000 gallons per minute (Tetra Tech, 2003). The United States Environmental Protection Agency (USEPA) has designated the Cape Cod Aquifer as a sole-source aquifer. The source of natural fresh water recharge to the aquifer is rainfall and snowmelt water that averages 43.9 inches per year. Approximately 45 percent (18 to 20 inches) of the average annual rainfall infiltrates the soil, replenishing groundwater supplies. Almost half of the annual precipitation is lost through surface evaporation and evapotranspiration.

Osborne Pond's elevation is about 60 feet above sea level. Surface water in the immediate area drains toward the pond. The local groundwater gradient is to the southwest toward Buzzards Bay.

1.2.5 Natural Resources

MMR contains the single largest tract of open space on Cape Cod. It serves as an important refuge for wildlife that requires large ranges of interior forest habitat. The biological and ecological significance of MMR is extremely high. Much of the area consists of pitch pine and scrub oak barrens and thickets. It is one of the largest remaining habitats of that type in the northeastern United States [Massachusetts Nation Guard et al, (MANG et al), 2001]. The Natural Resource / Integrated Training Area Management (ITAM) Office on Camp Edwards, a department within the MAARNG's Construction Facilities Management Office (CFMO), provides (site)specific information about rare species found in the MMR.

1.3 SITE HISTORY AND LAND USE

This section presents site-specific historical information including land use over the years.

1.3.1 Site History

Osborne Pond is a small water body located within the Camp Edwards cantonment area. Camp Edwards was established in 1938 as a training site for the Massachusetts National Guard.

Camp Edwards was federalized from 1940 to 1946, training tens of thousands of Army soldiers for World War II. Between 1946 and 1950, use of Camp Edwards reverted back to the Massachusetts National Guard. The post was again federalized from 1950 to 1952 to train soldiers for the Korean Conflict. After that time, Camp Edwards was transferred to establish Otis Air Force Base, Air National Guard Base

(ANGB) which lasted until 1976. At that time, the base was reconfigured and divided between the Massachusetts Army National Guard (MAARNG) (Camp Edwards), the Massachusetts Air National Guard (Otis Air National Guard Base), and the USCG (WWW.MMR.ORG).

A Former Bivouac Area is located to the west and southwest of the Site (Figure 1-1). The Osborne Pond Site was not a known target or disposal/dump area; however, an interview with a former Air Force Reserves trainee, otherwise known as "Witness 32," stationed at MMR from 1963 through 1973 indicated that a disposal area was possibly located in Osborne Pond. The witness recalled a picture in a newspaper article in the summer of 1968 or 1969 in which low water levels resulting from a drought exposed mortar rounds, grenades, and artillery shells. The report of this newspaper article or photograph could not be corroborated and a copy could not be located. The witness did not have any first-hand knowledge regarding munitions disposal at the site. The reliability of this information is reduced due to the fact that it is second-hand information, uncorroborated, and in excess of forty years old. A 1947 aerial photograph of the area depicts a road from the Site to a former ammunition supply point (ASP) a quarter-mile south of the Osborne Pond water body (Figure 1-2).

1.3.2 Property Land Use

MMR has three main use areas as stated below.

- The cantonment area in the southern part of the reservation where the USCG, Army National Guard, and Air National Guard facilities are located. Aircraft runways, maintenance areas, access roads, housing, and support facilities are found in this 5,500-acre area.
- The northern 14,700-acre area, also known as Camp Edwards, which is used primarily by the Army National Guard. This area contains the 2,200-acre Impact Area, former mortar and artillery firing points, a former rocket range, active and inactive small arms training ranges and the USCG Communication Station/Transmitter Site for Air Station, Cape Cod.
- The 750-acre Veterans Administration Cemetery is located in the southwestern corner of the reservation (WWW.MMR.ORG).

The Site is located within the cantonment area adjacent to the USCG housing area. This area, located just west of the airfield, houses the installation's main complex of offices, classrooms, and laboratories. The wastewater treatment facility and the Upper Cape Regional Transfer Station are also located in the cantonment area, near the southern boundary of the base. Shops and maintenance facilities for the Army National Guard, United States Marine Corps facilities, and a United States Department of Agriculture research facility, as well as a chapel and gymnasium, are located in the central portion of the cantonment area. Grassland areas in the central cantonment area provide habitat for several species of rare grassland birds. The current Unit Training Equipment Site, where the Army National Guard stores and maintains its vehicles, is located at the northern edge of the cantonment area near the Sandwich Gate (Tetra Tech, 2003).

The Osborne Pond Site is considered a recreational area and is located adjacent to the USCG housing area. Fishing, canoeing, swimming, and other motor boating are not permitted at this time. Signs posted around the perimeter of the pond indicate that swimming and boating are not permitted. Aerial photographs from 1995 indicate that about 80 percent of the pond is buffered by at least 100 feet of tree cover/heavy vegetation and about 50 percent of that land has a 10 to 50-foot shore width to the tree line. The unoccupied Stone School is located approximately 450 feet to the southwest of the pond. There is no septic drainage into the Osborne Pond water body. Nine storm drain outfall lines discharge into the pond.

1.4 SUMMARY OF PREVIOUS INVESTIGATIONS

This section presents groundwater studies and geophysical investigations conducted to date at the Site and surrounding areas.

1.4.1 Ground Water Study, 1996 to Present

The cleanup efforts at MMR are comprised of two major programs: the Installation Restoration Program (IRP) and the Impact Area Groundwater Study Program (IAGWSP). The IAGWSP is focused on the northern half of the base in and around the impact area and its associated firing ranges.

The IRP is primarily focused on the southern side of the MMR in and around the cantonment area. The IRP is focused on identifying and remediating or monitoring 13 groundwater contamination plumes resulting from activities that occurred on that part of Camp Edwards. The IRP is not subject to Administrative Orders, but is managed as a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) investigation. The Site is located on the IRP side of the MMR, but is being managed as a Formerly Used Defense Site (FUDS) project with State and Federal regulatory oversight.

1.4.2 Osborne Pond Geophysical Mapping, August 2003

Digital geophysical mapping of the Osborne Pond water body was conducted between August 9, 2003 and August 11, 2003 (Figure 1-3). A USAESCH shallow marine digital magnetometer system was used for data collection. The objective of the mapping effort was to locate magnetic anomalies associated with munitions and explosives of concern (MEC) on or buried beneath the pond bottom. MEC items are military munitions that may pose unique explosive risks, including: (a) unexploded ordnance (UXO); (b) discarded military munitions (DMM); or (c) munitions constituents (MC) (e.g., trinitrotoluene), present in high enough concentrations to pose an explosive hazard. DMM are military munitions that are unfired and have been abandoned without proper disposal or have been removed from storage in a military magazine or other storage area for the purpose of disposal. DMM items are still capable of functioning.

Although there is no septic drainage into the Osborne Pond water body, there are nine storm drain outfalls emptying into the pond. Some of the magnetic anomalies identified along the shore of the pond correspond with storm drains (USAESCH, 2003).

1.4.3 Engineering Evaluation and Cost Analysis, 2005-2006

The 2006 Engineering Evaluation/Cost Analysis (EE/CA) included performing intrusive investigations and environmental sampling at the Osborne Pond Site. The area of interest was based on the geophysical data collected in 2003 and 2005. This work was considered a Phase I investigation of the Site.

As part of the EE/CA, digital geophysical mapping (DGM) of the upland area adjacent to the Osborne Pond Site was conducted in 2005 using a digital magnetometer system for data collection (Figure 1-3). The objective of the project was to locate magnetic anomalies potentially associated with MEC on or beneath the ground surface and within the pond.

The acreage surveyed was increased from the area defined in the original scope of work, which was limited to the high to low water shoreline area immediately surrounding the pond, to include the Former Bivouac Area west and southwest of the Osborne Pond water body. The Former Bivouac Area is comprised of 14 acres, 10.5 of which are undeveloped and selected for investigation (the area, equaling approximately 3.5 acres, surrounding Stone School was excluded as it has been re-graded since closure of the former bivouac area). Geophysical mapping was conducted on single-line (3-foot wide) transects oriented east-west and placed approximately 15 meters apart, with additional transects where roads had

been depicted on the historic aerial photos. Additionally, eleven locations were selected at apparent pedestrian access points around the perimeter of the Osborne Pond water body for geophysical survey. A total of 1.34 acres, or 12.7 percent, of the 10.5 acres was surveyed. Since magnetometers detect larger and/or shallow metal objects well beyond this 1.5-foot radius or 3-foot width, objects similar in size and depth to the DMM item would have been recovered a minimum of 3 feet off line (i.e., a 6-foot swath) and likely even further. Therefore, the coverage for detection/recovery of items resembling the DMM is at least twice that reported (swath width of 6 feet or 2.68 acres), resulting in a conservative calculation of 25.5 percent coverage for shallow items.

A total of 807 land-based magnetic anomalies identified during the survey were intrusively investigated. Of these, 781 were selected anomalies identified from DGM and re-acquired. Twenty-six (26) additional contacts not on the initial list were investigated in the field. The selection of the initial 781 anomalies was based on the geophysical response thresholds representing the response signature of a MKII grenade selected during the Technical Project Planning (TPP) process and demonstrated during the geophysical prove-out area investigation. Investigation results are assimilated in the EE/CA report. The single MEC item discovered during the intrusive investigation was an unfired high explosive anti-tank rocket (2.36-inch M6 series) with the ogive and fins rusted off and the cone laying outside of the body. The DMM item was found at a depth of two inches below ground surface approximately 65 feet from the edge of the Osborne Pond water body. The other 806 targets selected for investigation in the TPP process included assorted pieces of cultural debris (CD) consisting of nails, soda cans, ball bearings, steel rope, rebar, fence posts, discarded hand tools, fence wire, and various other ferrous items unrelated to military munitions. The DMM item found was turned over to the CENAE MMR UXO Safety Specialist on June 06, 2006 for disposal. The resulting intrusive data is presented in Table 1-1.

Soil samples were collected adjacent to the single MEC item identified during the 2006 intrusive investigation in order to test for the possible presence of munitions constituents (MC) related to the MEC item filler. Five soil samples were taken, including field Quality Control (QC) and QA samples. Each soil sample was tested for the presence of explosives, perchlorate, metals, and semi-volatile organic compounds (SVOC). Results of the analyses indicated the presence of the following explosives constituents immediately adjacent to and beneath the DMM item: 2,4,6-Trinitrotoluene, 2-Amino-4, 6-Dinitrotoluene, and 4-Amino-2,6-Dinitrotoluene. None of the soil samples contained concentrations of explosives constituents above applicable MCP soil standards or USEPA Region 9 Preliminary Remediation Goals (PRG) (HTTP://WWW.EPA.GOV/REGION9/SUPERFUND/PRG/FILES/04USERSGUIDE.PDF).

The EE/CA for the 2005-2006 field investigation of selected anomalies in the upland area adjacent to Osborne Pond was submitted in 2007 (Zapata, 2007). The results of the EE/CA field investigation effort are included in the Final EE/CA (Zapata, 2007). The EE/CA indicated the use of Institutional Controls (IC) as the recommended alternative for the upland area. The EE/CA recommended "posting of warning signs and distribution of informational pamphlets to area residents, workers, and students". In addition, it recommended "a Recurring Review be carried out every five years to assess the continued effectiveness of the periodic munitions and explosives of concern response activities" (Zapata, 2007). It should be noted that neither the Massachusetts Department of Environmental Protection (MassDEP) nor the USEPA concurred with this decision, citing the need for additional investigation in the upland area.

1.5 SUMMARY OF REMEDIAL INVESTIGATION FINDINGS, 2008

The objective of the Remedial Investigation (RI) was to characterize the Osborne Pond Site at MMR to determine the nature and extent of MC and MEC contamination. The activities conducted to achieve this objective included the following:

- Review and summarize the data relating to the presence of MEC collected during previous munitions investigations (Phase I investigation).
- Review relevant data associated with the on-going IRP monitoring.
- Conduct a focused investigation of selected targets using previously gathered geophysical data to reacquire and selected targets (Phase II investigation).
- Identify and analyze reasonable risk management alternatives to address actual site conditions as determined from the RI and EE/CA.

The Phase II field investigation was conducted from July 8, 2008 to July 14, 2008. As part of this effort, ECC used previously gathered geophysical data provided by USAESCH to reacquire and investigate 17 selected targets and five outfall areas within the Osborne Pond water body.

The sampling approach associated with the geophysical investigations was dynamic and iterative based on observations and findings from the MEC intrusive investigations. MEC items and/or munitions debris (MD) were not discovered within the pond during the intrusive field investigations. MD are remnants of munitions (e.g., fragments, penetrators, projectiles, shell casings, links, and fins) remaining after munitions use, demilitarization, or disposal. Sediment samples were to be collected if MEC items or MD were discovered during the geophysical investigation within the pond. Since no items were discovered, sediment samples were not collected.

Surface water samples were collected at three locations within the pond to demonstrate that there were no environmental impacts to the pond as a result of past activities. One sample was collected from a depth of 0.25 to 0.5 feet near Outfall #5, one sample and a field duplicate sample were collected from a depth of 0.25 to 0.5 feet near Outfall #1, and one sample was collected from a depth of 6.25 to 6.5 feet from the center of the pond.

The results for SVOC, explosives compounds, and perchlorate were non-detect in all samples. Only a few trace metal analytes were detected in the samples.

Sample results were compared to the Massachusetts Maximum Contaminant Levels (MMCL) (HTTP://WWW.MASS.GOV/DEP/WATER/DWSTAND.PDF) and to the Region 9 PRG (HTTP://WWW.EPA.GOV /REGION9/SUPERFUND/PRG/FILES/04USERSGUIDE.PDF). Aluminum, calcium, iron, magnesium, manganese, potassium, and sodium were detected in all surface water samples at comparable levels. There are no MMCLs for these common analytes. PRGs exist for aluminum, iron, and manganese; all surface water results were less than respective PRG values. Other analytes which were detected include: barium (two samples), cobalt (three samples), molybdenum (three samples), and silver (one sample). There are MMCLs for barium and silver and all reported results for these analytes were below their respective MMCLs. There are PRGs for barium, cobalt, molybdenum, and silver; and all reported results were below their respective PRG values.

The RI at the Osborne Pond Site was conducted to verify a remark made by a witness, alleging there was an article posted in a past issue of the Otis Notice Newspaper depicting MEC in the pond. Historical records review (HRR) could not confirm the alleged articles existence. Based on the archival data, historical and aerial photographs, documents and previously conducted site investigations, the RI concluded that the Site was not known as a munitions disposal area and/or as a range, additional investigations are not warranted, and there have been no adverse effects to the upland or pond areas.

1.6 REPORT ORGANIZATION

Section 2.0 presents the Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered criteria that must be addressed during any site remediation.

Section 3.0 identifies and screens remedial technologies for the corresponding response actions. This section links the results of the previous investigations to the selection of remedial technologies by developing remedial action objectives (RAO) and listing the resultant general response actions.

Section 4.0 describes the assembly of these technologies into remedial alternatives and evaluates the alternatives against the criteria of implementability, effectiveness, and cost.

Section 5.0 provides a detailed analysis of the alternatives and contains an assessment of each alternative against the first seven evaluation criteria listed in the National Contingency Plan (NCP). This section concludes with a comparison of the alternatives that were the focus of the detailed evaluation, highlighting relative advantages and disadvantages of the alternatives with respect to the seven evaluation criteria.

Tables, figures, and appendices are presented at the end of this document.

2. APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDERED CRITERIA

ARARs are restrictions or regulations that must be satisfied during site remediation. ARARs play an important role in determining which remedial alternatives, if any, may be applied to a site.

Title 40 of the U.S. Code of Federal Regulations defines ARARs as follows: *Applicable requirements means those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable.*

Relevant and appropriate requirements means those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site. Only those state standards that are identified in a timely manner and are more stringent than federal requirements may be relevant and appropriate. (40 CFR 300.5, 1991)

Three categories of ARARs have been evaluated for this FS as follows:

- Chemical-specific ARARs are health-based or risk-based numerical values that establish the acceptable amount or concentration of a chemical that may remain in, or be discharged to, the ambient environment. Preliminary chemical-specific ARARs were identified in the RI and no chemical constituents detected at the Osborne Pond Site exceeded the criteria. Therefore, no chemical-specific ARARs are identified for exposure to MC for the Site.

- Location-specific ARARs generally are restrictions placed on the concentration of hazardous substances or the conduct of activities to prevent damage to unique or sensitive areas, such as floodplains, wetlands, historic places, and sensitive ecosystems or habitats.

- Action-specific ARARs are usually technology or activity-based requirements or limitations placed on actions taken with respect to clean-up actions, or requirements to conduct certain actions to address particular circumstances at a site.

In addition to legally binding requirements established by ARARs, many State and Federal programs have developed criteria, advisories, guidance, and proposed standards that are not legally binding. These items are known as To Be Considered criteria.

A summary of ARARs and To Be Considered criteria identified for the Site and determinations regarding their applicability are provided in Table 2-1.

3. IDENTIFICATION AND SCREENING OF TECHNOLOGIES

This section identifies and screens remedial technologies using the process outlined in USEPA RI/FS guidance and the NCP (USEPA, 1988). The process begins with the identification of remedial response objectives which establish general cleanup goals and identification of ARARs. Next, chemical-specific numerical cleanup goals are typically established and, in conjunction with remedial response objectives and ARARs, used to identify RAOs. Once these tasks are completed, estimates are made of the areas and volumes of media which exceed numerical cleanup goals, and potential cleanup technologies are identified and screened to produce an inventory of suitable technologies that can be assembled into remedial alternatives capable of mitigating risks at the site.

3.1 REMEDIAL ACTION OBJECTIVES

The goal of a remedial action is to reduce explosives safety hazards and contaminants of concern to ensure protection of human health, public safety, and the environment. Contaminants of concern were not detected above USEPA PRGs, so remedial actions will not be focused on reducing concentrations of contaminants of concern. Also, since DMM was the only type of MEC found at the site, RAOs will be focused on significantly reducing the risk of direct contact with potential DMM by human receptors conducting surface recreational activities. Based on the results of the RI Report (ECC, 2010) and consistent with the EE/CA (Zapata, 2007), it is the opinion of the USACE that the area to be considered for further action is the area comprised of the undisturbed portion of the Former Bivouac Area (10.5 acres), especially picnic areas, walking paths, and any cleared areas within the Former Bivouac Area where people are likely to linger (approximately three acres based on aerial photography).

The RAOs guide the development of alternatives and focus the comparison of acceptable remedial action alternatives, if warranted. Access to the MMR and the Osborne Pond Site is controlled by manned security gates, which prevent access to the Site by the general public. The Osborne Pond Site is located adjacent to the USCG housing area and is currently considered a recreational area. Fishing, canoeing, swimming, and other motor boating are not permitted at this time. Signs posted along the perimeter of Osborne Pond indicate that swimming and boating are not permitted. The future use of the property is expected to continue to be recreational. Likely receptors include adults who work on the MMR or adults and children that live in military housing on the MMR.

The RAO for DMM at the Site is to:

- Significantly reduce the risk of direct contact with potential DMM by human receptors conducting surface recreational activities.

3.2 GENERAL RESPONSE ACTIONS

General response actions are those actions that will achieve the RAO. The following general response actions will be considered for the Site:

- **No Action** – The No Action alternative is evaluated to satisfy the NCP requirement of 40 CFR 300.430(e)(6), which requires consideration of this alternative as a baseline against which other alternatives may be compared.
- **Public Education** – Public education utilizes a Public Education Program to provide risk management through education of the local populace, specifically residents, base personnel, workers and visitors who may be exposed to a potential hazard. Some DMM may always remain at the site; thus, public education is included as a component of all remedial alternatives. Public education is considered a “limited” action alternative by the USEPA(USEPA, 1988).

- **Removal** – DMM can be detected, recovered, and disposed from the ground surface and/or below the ground surface. Alternatives for removal will include technologies for detection, recovery, and disposal.

3.3 IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES

DMM remedial technologies are identified and evaluated against the three general categories of effectiveness, implementability, and cost. The three general categories are initially used to screen the technologies described in subsection 3.4 and later used, as necessary, to screen the remedial alternatives developed in subsection 4.1. The three general categories for the technology screening are described below.

3.3.1 Effectiveness

Technologies that have been identified will be evaluated further on their effectiveness relative to other processes within the same technology type. This evaluation will focus on:

- The potential effectiveness of technology options in handling the estimated areas or volumes of media and meeting the remediation goals identified in the FS;
- The potential impacts to human health and the environment during the construction and implementation phase; and
- How proven and reliable the technology is with respect to the conditions at the Site (USEPA, 1988).

3.3.2 Implementability

Implementability is a measure of both the technical and administrative feasibility of constructing, operating, and maintaining a remedial action technology, and is used during screening to evaluate the combinations of technology options with respect to conditions at a specific site. Technical feasibility refers to the ability to construct, reliably operate, and meet technology-specific regulations for technology options until a remedial action is complete. It also includes operation, maintenance, replacement, and monitoring of technical components of a technology, if required, into the future after the remedial action is complete.

Administrative feasibility refers to the ability to obtain approvals from other offices and agencies; the availability of treatment, storage, and disposal services and capacity; and the requirements for, and availability of, specific equipment and technical specialists (USEPA, 1988).

The determination that a technology/alternative is not technically feasible will usually preclude it from further consideration unless steps can be taken to change the conditions responsible for the determination. Typically, this type of "fatal flaw" will be identified during technology screening and an alternative consisting of infeasible technology will not be assembled. Negative factors affecting administrative feasibility will normally involve coordination steps to lessen the negative aspects of the technology/alternative but will not necessarily eliminate a technology/alternative from consideration (USEPA, 1988).

3.3.3 Cost

Typically, technologies/alternatives will have been defined well enough before screening that some estimates of cost are available for comparisons among technologies/alternatives. However, because uncertainties associated with the definition of technologies/alternatives often remain, it may not be

practicable to define the costs of technologies/alternatives with the accuracy desired for the detailed analysis (i.e., +50 percent to -30 percent) (USEPA, 1988).

According to USEPA guidance, a high level of accuracy in cost estimates during screening is not required. The focus should be to make comparative estimates for technologies/alternatives with relative accuracy so that cost decisions among technologies/alternatives will be sustained as the accuracy of cost estimates improves beyond the screening process.

In the detailed analysis in Section 5.0, when the costs of remedial action alternatives are evaluated, both capital and operation and maintenance (O&M) costs will be considered, where appropriate. The evaluation will include those O&M costs that will be incurred for as long as necessary, even after the initial remedial action is complete. In addition, potential future remedial action costs will be considered during alternatives evaluation to the extent they can be defined. Present worth analyses will be used during alternatives evaluation to evaluate expenditures that occur over different time periods. By discounting all costs to a common base year, the costs for different technologies/alternatives can be compared on the basis of a single figure for each alternative. Included in each cost calculation is an estimate as to the amount of time that will be necessary to complete the proposed alternative.

3.4 EVALUATION OF TECHNOLOGIES

Technologies and approaches developed for remediation of the broader category of MEC encompass those technologies and approaches for remediation of DMM. Descriptions of the technologies used in each step are presented in the following subsections. At the end of each subsection, the technologies are screened against the three screening criteria to determine their viability at the Site.

3.4.1 Detection Technologies

MEC detection includes the methods and instruments used to locate surface and subsurface MEC. The best detection method is selected based on the MEC properties, such as the depth and size of the suspected MEC items, and the physical characteristics of the site, such as soil type, topography, vegetation, and geology.

There are two basic forms of MEC detection: visual searching and geophysics. Visual searching has been successfully used on a number of sites where MEC is located on the ground surface. When performing a visual search of a site, the area to be searched is typically divided into five-foot lanes that are systematically inspected for MEC. A metal detector is sometimes used to supplement the visual search in areas where ground vegetation may conceal surface MEC. Typically, any MEC found during these searches is flagged or marked on a grid sheet for immediate removal.

Geophysics includes a family of detection instruments designed to locate subsurface MEC. These detection instruments are coupled with equipment and methods used for global positioning so that anomalies can be mapped and relocated, as necessary. The family of instruments designed to locate subsurface MEC includes magnetic and electromagnetic instruments. Each piece of equipment has its own inherent advantages and disadvantages based on its operating characteristics, making the selection of the type of geophysical instrument critical to the survey success.

Positioning technologies include various methods and instruments that establish geo-referenced data for anomalies located using MEC detection technologies. Each method and/or instrument has its own inherent advantages and disadvantages based on its operating characteristics, making the selection of the type of positioning method important to ensure survey reproducibility. Positioning technologies are impacted on site primarily by terrain, including canopy, the density of trees, and topography.

MEC detection technologies and positioning technologies are described and screened in Tables 3-1 and 3-2, respectively. Tables 3-1 and 3-2 are based on the Final MMRP RI/FS Guidance (Army, 2009).

3.4.2 Recovery Technologies

The recovery of MEC is initiated after completion of either a visual or geophysical survey of the site. MEC recovery operations include surface-only clearance, subsurface clearance, or a combination of the two methods. The appropriate level of clearance required for each site is based on the nature and extent of the MEC, current land use, and intended future land use of the site.

Surface clearance includes relocating and investigating exposed MEC and geophysical anomalies. Once the anomalies are located, the MEC items are inspected, identified, recovered, and transported to a designated area for cataloging and eventual disposal. If it is determined during the MEC inspection that the risk of moving an item is unacceptable, then the MEC item is typically destroyed in place.

Potential MEC items identified during a subsurface clearance operation by the geophysical survey or other detection methods require excavation for removal or detonation. The type of the buried MEC item cannot be determined without it being uncovered; thus, nonessential personnel evacuations are typically required within a predetermined minimum separation distance (MSD). The MSD is based on the munition with the greatest fragmentation distance that may be present. All non-essential personnel and the general public must be evacuated from and maintain their distance beyond the MSD during the intrusive operations. The MSD may be reduced if sufficient engineering controls are implemented.

Excavation of the potential MEC item takes place with either hand tools or mechanical equipment depending on the suspected depth of the object. Once the MEC item has been exposed, it is then inspected, identified, collected (if possible), and transported to a designated area for cataloging and disposal. If it is determined during the inspection that the item is MEC and the risk of moving the item is unacceptable, then it may be necessary to destroy the MEC item in place. In such cases, the MSD is imposed on all personnel for intentional detonations. The MSD may be increased or decreased based on the actual identified MEC item. The MSD may also be reduced if appropriate engineering controls are applied. However, evacuations may be required if excavations are conducted close to inhabited areas and engineering controls cannot reduce the MSD to preclude the need to evacuate. Every possible option will be explored to minimize the potential evacuations with the exception of compromising public safety.

MEC recovery technologies are described in Table 3-3 and screened against the three criteria of effectiveness, implementability, and cost and are based on the Final MMRP RI/FS Guidance (Army, 2009).

3.4.3 Disposal Technologies

Disposal of recovered MEC can take one of three different forms: off-site demolition and disposal; remote, on-site demolition and disposal; and in-place demolition and disposal. The decision regarding which of these techniques to use is based on the risk involved in employing the disposal option, as determined by the specific area's characteristics and the nature of the MEC items recovered.

Due to the Site's proximity to the on-base housing, it is preferable for any identified MEC item to be moved to a remote part of the base where demolition and disposal can safely take place. However, situations may arise where an MEC item cannot be moved due to fuzing or deteriorated condition. These situations will need to be addressed on a case-by case basis.

If it is not acceptable to move a MEC, the item will be blown-in-place (BIP). When employing this technique, procedures similar to those described above are used that will detonate the MEC item. When this technique is employed, engineering controls, such as sandbag mounds and sandbag walls over and around the MEC item, are often used to minimize the blast effects.

All MEC disposal technologies generate a waste stream which must be addressed when determining which technologies are most viable. The waste streams generated by MEC disposal technologies include MC and/or MD. If the waste generated includes MC, then the waste stream may need to undergo additional treatment prior to final disposal. If the waste generated includes only MD, then additional treatment may not be necessary.

MEC disposal technologies are described in Table 3-4 and screened against the three criteria of effectiveness, implementability, and cost for the Site. Treatment technologies for the waste streams generated by MEC disposal technologies are described in Table 3-5. Disposal and treatment technologies are based on the Final MMRP RI/FS Guidance (Army, 2009).

3.5 RETAINED TECHNOLOGIES

Of the technologies evaluated in the sections above, the technologies presented in Table 3-6 have been retained for assembly into remedial alternatives.

4. DEVELOPMENT AND SCREENING OF ALTERNATIVES

This section combines the retained technologies for the Site in Section 3.0 and the general response actions to develop remedial alternatives. The remedial alternatives that are determined to be appropriate for the Site will be screened against the NCP criteria in the detailed analysis presented in Section 5.0.

4.1 DEVELOPMENT OF ALTERNATIVES

Remedial alternatives are developed in the following subsections and are summarized in Table 4-1. CERCLA requires that remedial actions that do not eliminate risk to human health and the environment be evaluated, at a minimum, every five years to assure that human health and the environment continue to be protected. The reviews determine if a remedial action continues to minimize explosives safety hazard and continues to be protective of human health, safety, and the environment, and provide an opportunity to assess the applicability of new technologies to address site issues. Five-year reviews are included in each alternative except Alternative 1 – No Action.

4.1.1 Alternative 1 – No Action

The "No Action" alternative is evaluated to satisfy the NCP requirement of 40 CFR 300.430(e)(6), which requires consideration of this alternative as a baseline against which other alternatives may be compared. This alternative includes no remedial activities at the Site to mitigate potential hazards posed by the possible presence of DMM at the Site. In addition, there would be no implementation of public education or awareness programs. This alternative assumes continued use of the Site in its present state.

4.1.2 Alternative 2 – Public Education

This alternative utilizes a Public Education Program to reduce direct contact with DMM potentially present at the site. The Public Education Program includes installation and maintenance of warning signs and distribution of DMM safety educational media to base residents, personnel, site workers, and visitors. The Public Education Program will provide effective risk management by educating the local populace of the potential explosive risks at the site including the potential presence of DMM, how to identify DMM, how to avoid contact, and who to contact if DMM is encountered. This education would be facilitated through the distribution of educational materials to base residents and personnel.

The USACE will work with the USCG to ensure that educational material is distributed to the local residents, school children and their families, and recreational users. In addition, educational packages will be distributed to local police, fire departments, and libraries, where they will be available to the public. Public safety awareness meetings will be conducted annually for the general public and land users within the Site.

4.1.3 Alternative 3 – Limited Subsurface Clearance of Recreational Areas with Public Education

This alternative combines removal and disposal of potential DMM from the ground and limited subsurface of recreational areas and public education. The recreational areas include the picnic areas, walking paths, and de-vegetated areas within the Former Bivouac Area where people are likely to linger, and the area around the location of the DMM item found at the Site (3 acres). These areas are identified on Figure 4-1 by orange and green hatch-marks. Components of this alternatives include:

- Implement the Public Education Program (warning signs, safety meetings, and education materials);
- Survey and subdivide the recreational areas into smaller work sectors;
- Cut a minimal amount of brush and shrubs in the recreational areas of the Former Bivouac Area to allow for safe removal of limited subsurface DMM and MD;

- Screen for DMM and MD using an all metals detector and remove if visible on the ground or limited subsurface. Clearance contractor will also use a handheld shovel or similar equipment to check for near-surface (0-3”) items;
- Perform explosive demolition of DMM found at the site; and
- Transport non-hazardous MD for offsite treatment and disposal.

If any DMM are found at the Site, recovery will be conducted by hand excavation of individual anomalies. DMM disposal will be conducted by BIP or contained detonation chamber (CDC). MMR BIP procedures, in their entirety, will be followed. The most current procedures are the Final Addendum to the Final Revised BIP Field Sampling and Excavation plan dated 17 August 2004 and the Final Revised BIP Field Sampling Plan dated 6 December 2002. Recycling will be used to dispose of MD. The Public Education Program will be implemented as described in Alternative 2 in subsection 4.1.2.

4.1.4 Alternative 4 – Subsurface Clearance of Recreational Areas with Public Education

Alternative 4 combines removal and disposal of potential DMM from the ground surface and the subsurface of recreational areas along with public education. The recreational areas include the picnic areas, walking paths, and de-vegetated areas within the Former Bivouac Area where people are likely to linger, and the area around the location of the DMM item found at the Site (3 acres). These areas are identified on Figure 4-1 by orange and green hatch-marks. The components of this alternative include:

- Implement the Public Education Program (warning signs, safety meetings, and education materials);
- Survey and subdivide the recreational areas into smaller work sectors;
- Cut a minimal amount of brush and shrubs in the recreational areas of the Former Bivouac Area to allow for safe removal of surface DMM and MD;
- Screen for DMM and MD using an all metals detector and remove items from both the ground surface and buried below the ground surface;
- Perform explosive demolition of DMM found at the site; and
- Transport non-hazardous MD for offsite treatment and disposal.

If any DMM are found at the Site, recovery will be either hand excavation or mechanized removal of individual anomalies. Anomalies that are detected deeper than one foot below ground surface may be excavated using mechanical equipment. In accordance with USACE safety procedures, a backhoe will only be used to excavate no closer than 12 inches of anomalies. Hand excavation will then be used to recover the item.

DMM disposal will be conducted by BIP or CDC. MMR BIP procedures, referenced under Alternative 3, will be followed. Recycling will be used to dispose of MD. The Public Education Program will be implemented as described in Alternative 2 in subsection 4.1.2.

4.1.5 Alternative 5 – Complete Clearance of Former Bivouac Area with Public Education

This alternative includes all elements of the Alternative 4, but the surface and subsurface removal of DMM would extend over a greater area. Appropriate geophysical equipment will be selected with the consultation of stakeholders during the planning process for the proposed action. For Alternative 5, surface and subsurface removal of DMM would be conducted across all undisturbed portions of the former bivouac area (10.5 acres) delineated by the blue line on Figure 4-1. The area for surface and subsurface removal encompasses the recreational areas described in Alternatives 3 and 4. This alternative also includes all the elements of Alternative 2. The components of this alternative include:

- Implement the Public Education Program (warning signs, safety meetings, and education materials);
- Survey and subdivide the recreational areas into smaller work sectors;
- Cut a minimal amount of brush and shrubs in the Former Bivouac Area to allow for safe removal of surface DMM and MD;
- Remove DMM and MD from the ground surface and buried below the ground surface in the undeveloped areas of the Former Bivouac Area;
- Perform explosive demolition of DMM found at the Site; and
- Transport non-hazardous MD for offsite treatment and disposal.

Recovery and disposal of any DMM found at the site will be as described under alternatives 3 and 4. The Public Education Program will be implemented as described in Alternative 2 in subsection 4.1.2.

4.2 SCREENING OF INDIVIDUAL ALTERNATIVES

The technologies combined to form the remedial alternatives summarized in Table 4-1 have been screened against the three criteria of effectiveness, implementability, and cost, and are deemed highly viable at the Site in Section 3. Therefore, all five remedial alternatives will be carried forward into the detailed analysis conducted in Section 5.

5. DETAILED ANALYSIS OF ALTERNATIVES

The USEPA has established the following nine criteria against which each potential remedial alternative must be evaluated and compared to one another. The detailed analysis of alternatives in this FS evaluates the first seven criteria; the last two criteria are evaluated during the public comment period on the proposed plan before the final Decision Document is signed (USEPA, 1988).

1. Overall protection of human health and the environment
2. Compliance with ARARs
3. Long-term effectiveness and permanence
4. Reduction of toxicity, mobility, or volume through treatment
5. Short-term effectiveness
6. Implementability
7. Cost
8. State acceptance
9. Community acceptance

The first two criteria, overall protection of human health and the environment and compliance with ARARs, are threshold criteria that represent basic requirements any alternative must satisfy. Therefore, each alternative must meet these minimum requirements in order to be eligible for selection. The next five criteria – long term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost – are primary balancing criteria that form the basis for comparing alternatives in light of site-specific conditions. The last two criteria, State acceptance and community acceptance, are modifying criteria and will be fully evaluated following the comment period on the proposed plan, and while a final decision is being made and the Decision Document is being prepared (USEPA, 1988). The detailed analysis of alternatives evaluated each remedial alternative against the threshold criteria and the primary balancing criteria. Each of these criteria is discussed in detail in Section 4.2.1 and Section 4.2.2.

5.1 EVALUATION CRITERIA

Remedial alternative evaluation criteria are described in the NCP, Section 300.430. The criteria were developed to address the CERCLA requirements and considerations, and to address the additional technical and policy considerations that have proven to be important for selecting remedial alternatives. These evaluation criteria serve as the basis for conducting the detailed analyses during the FS and for subsequently selecting an appropriate remedial action.

The evaluation criteria have been divided into three groups based on the function of the criteria in remedy selection. The threshold criteria relate to statutory requirements that each alternative must satisfy in order to be eligible for selection. The threshold criteria are described below.

1. Overall Protection of Human Health and the Environment – This criterion determines whether an alternative achieves the RAOs by eliminating, reducing, or controlling threats to public health and the environment. This is achieved through education, land use controls, engineering controls, or treatment of the hazard. The evaluation is based on potential risk factors associated with the Site: the potential presence of DMM, the Site's physical characteristics, and the presence of humans in and around the Site. An emphasis is placed on effectiveness in terms of worker safety issues during remedial actions and post-remedial action for local residents and workers based on current and future land use.

2. Compliance with Federal and State Regulations – This criterion evaluates whether the alternative meets Federal and State environmental statutes, regulations, and other requirements that

pertain to the site, or whether a waiver is justified. A summary of the ARARs is presented in Section 2.0.

The primary balancing criteria are the technical criteria upon which the detailed analysis is primarily based and are described below.

3. Long-Term Effectiveness and Permanence – This criterion considers the ability of an alternative to maintain protection of human health and the environment over time. Long-term effectiveness and permanence evaluates the magnitude of residual risk and the adequacy and reliability of controls to manage the residual risk. For MEC sites, this will typically include controls that include physical mechanisms (e.g., fences, signage, etc.), education, and legal mechanisms (e.g., updates to the Real Property Master Plan, equitable servitudes, deed notifications, etc.). The long-term effectiveness and permanence of controls take into account the administrative feasibility of maintaining the controls and the potential risk/hazard should they fail.

4. Reduction of Toxicity, Mobility, or Volume (TMV) of Contaminants through Treatment – Section 121 (Cleanup Standards) of CERCLA states a preference for remedial actions that permanently and significantly reduce the volume, toxicity, or mobility of contaminants as the primary element of the action. This criterion addresses the capacity of the alternative to reduce the principal risks through destruction of contaminants, reduction in the total mass of contaminants, irreversible reduction in the contaminant mobility, or reduction in the total volume of contaminated media. This criterion evaluates an alternative's use of treatment technologies that permanently and significantly reduce TMV of the DMM or MC as a principal element of the remedy. For DMM, the toxicity and mobility factors are not specifically relevant, unless the DMM item is corroded or cracked, and leaking. Therefore, the reduction of volume, or removal of DMM, is often the primary factor for DMM. For DMM sites where the disposal options are generally limited (e.g., blown-in-place, consolidated shot, CDC), the destruction of the DMM is considered as treatment that reduces the volume of DMM at the site.

5. Short-Term Effectiveness – This criterion considers the impacts of an alternative's construction and operational phases, including worker and community safety, as well as ecological impacts, socioeconomic impacts, and cultural impacts during the construction and implementation phase until remedial response objectives are met. Short-term effectiveness also includes the duration for completion of the remedial action.

6. Implementability – This criterion considers the technical and administrative feasibility of implementing the alternative. Technical feasibility considerations include the reliability of the technology; the availability of required services, materials, and equipment; potential construction difficulties; and potential system modification needs. Administrative feasibility considerations include coordination with agencies, and access and permitting requirements and procedures in order to carry out construction, maintenance, and monitoring.

7. Cost – This criterion includes estimated capital and annual operations and maintenance (O&M) costs, as well as present value cost. Present value cost is the total cost of an alternative over time in terms of today's dollar value. Cost estimates are expected to be accurate within a range of +50 to -30 percent.

The third group is made up of the modifying criteria and includes:

8. State Agency Acceptance – This criterion considers whether the State (MassDEP) concurs with the analyses and recommendations, as described in the FS. Because the Osborne Pond FUDS is

located within the borders of the MMR, USEPA will work collaboratively with MassDEP to determine State Agency Acceptance.

9. Community Acceptance – This criterion considers whether the local community agrees with the analyses and preferred alternative. Comments received on the FS and Proposed Plan are an important indicator of the community's acceptance of the alternatives.

The modifying factors will be addressed after receipt of comments on the FS and the Proposed Plan.

5.2 INDIVIDUAL ANALYSIS OF ALTERNATIVES

The following remedial alternatives will be evaluated against the NCP criteria in Subsection 5.1:

- Alternative 1 – No Action;
- Alternative 2 – Public Education;
- Alternative 3 – Limited Subsurface Clearance of Recreational Areas with Public Education;
- Alternative 4 – Subsurface Clearance of Recreational Areas with Public Education; and
- Alternative 5 – Complete Clearance of the Former Bivouac Area with Public Education.

The remedial alternatives are described in section 4.1 and summarized in Table 4-1.

5.2.1 Alternative 1 – No Action

Alternative 1 – No Action is evaluated relative to the NCP criteria for the Site as follows:

1. **Overall Protectiveness of Human Health and the Environment** – Based on the results of the investigations conducted to date at the Site, the probability of encountering DMM is considered to be low. The No Action alternative would not address the potential risk at the Site and, therefore, would not be protective of human health if additional DMM are present.

   Alternative 1 would be protective of the environment because no clearing, grubbing, or excavation would be required.

2. **Compliance with Federal and State Regulations** – There are no location or action-specific ARARs applicable to the No Action alternative because there are no active remedial actions associated with this alternative.

3. **Long-Term Effectiveness and Permanence** – Based on the results of the MEC investigations conducted to date at the Site, the probability of encountering DMM is considered to be low; however, Alternative 1 would not reduce the magnitude of risk over the long term if DMM are present. Alternative 1 requires no technical components and poses no uncertainties regarding its performance.

4. **Reduction of TMV of Contaminants Through Treatment** – Although the probability of additional DMM is low, Alternative 1would not reduce the volume of potential DMM remaining at the Site.

5. **Short-Term Effectiveness** – There would be no additional risk to the community or workers because there are no construction or operation activities associated with Alternative 1. There would be no impact to the environment because this alternative does not include clearing and grubbing.

6. **Implementability** – Implementation of Alternative 1 poses no technical or administrative difficulties.

7. **Cost** – Since there is no action associated with Alternative 1, the total present value cost to perform this alternative is $0. Cost estimates are presented in Appendix A.

5.2.2 Alternative 2 – Public Education

Alternative 2 – The Public Education Program is evaluated relative to the NCP criteria for the Site as follows:

1. **Overall Protectiveness of Human Health and the Environment** – Based on the results of the MEC investigations conducted to date at the Site, the probability of encountering DMM is considered to be low. The Public Education Program (education materials and meetings, signage) would raise public awareness and modify public behavior related to the activities they perform in and around the Site, which would result in increased protection of human health.

2. **Compliance with Federal and State Regulations** – The only activity under Alternative 2 that would occur on the Site is the installation of signs. The installation of the signs would have limited impact and would be implemented to comply with all ARARs and To Be Considered criteria.

3. **Long-Term Effectiveness and Permanence –** Alternative 2 is contingent on the cooperation and active participation of the existing powers and authorities of government agencies. The Public Education Program will specify steps and controls to be put in place that will ensure that Public Education is maintained, thus, ensuring long-term effectiveness, and permanence. The components of the Public Education Program, as described in Subsection 4.1.2, include installation and maintenance of signs, distribution of education materials, and participation in meetings. Site reviews would be conducted once every five (5) years as required by CERCLA to assess the site condition and the degree of protectiveness to human health and the environment.

4. **Reduction of TMV of Contaminants Through Treatment** – Although the probability of additional DMM is low, Alternative 2would not reduce the volume of potential DMM remaining at the Site.

5. **Short-Term Effectiveness –** The only potential risk to workers associated with this alternative is the potential risk during the installation of sign posts at the Site. This risk is very low and would be mitigated by use of MEC avoidance during sign installation. There would be no additional risk to the community because there are no other construction or operation activities associated with Alternative 2. There would be no impact to the environment because this alternative does not include clearing and grubbing.

6. **Implementability** – All of the components included in Alternative 2 can be easily implemented because there are no technical difficulties associated with this alternative and the materials and services needed to implement this alternative are readily available. Operation and maintenance of the Public Education Program can be easily performed.

7. **Cost** – The total present value cost to perform Alternative 2 at the Site is $397,000. The cost details are presented in Appendix A. The cost includes five-year reviews for a 30-year period.

5.2.3 Alternative 3 – Limited Subsurface Clearance of Recreational Areas with Public Education

Alternative 3 – Limited Subsurface Clearance of Recreational Areas with Public Education is evaluated relative to the NCP criteria for the Site as follows:

1. Overall Protectiveness of Human Health and the Environment – Based on the results of the MEC investigations conducted to date at the Site, the probability of encountering DMM is considered to be low. However, if additional DMM are present, Alternative 3 would provide increased protectiveness of human health due to the identification and removal of any DMM located at the ground surface within the picnic areas, walking paths, and de-vegetated areas within the Former Bivouac Area where people are likely to linger. Based on the historic military use of the Site as a bivouac area, it is anticipated any potential DMM items would be located near the ground surface.

The Public Education Program would provide an additional level of protection of human health as discussed in Alternative 2.

2. Compliance with Federal and State Regulations – Surface removal activities and public education would be conducted to comply with ARARs and To Be Considered criteria.

3. Long-Term Effectiveness and Permanence – Surface removal of any identified DMM would provide long-term effectiveness by removing any DMM found at the ground surface. Based on the historic military use of the Site as a bivouac area, it is anticipated any potential DMM items would be located near the ground surface. Any DMM located below the ground surface will remain at the Site and could potentially move toward the surface through frost heave and erosion.

As discussed in Alternative 2, the Public Education Program would provide an additional measure of long-term effectiveness and permanence after the surface removal activities are completed.

4. Reduction of TMV of Contaminants Through Treatment – If DMM are found, surface removal would reduce the volume of DMM at the Site. Based on the historic military use of the Site as a bivouac area, it is anticipated any potential DMM items would be located near the ground surface.

The Public education component of Alternative 3 would not provide any reduction in the volume of DMM.

5. Short-Term Effectiveness – If found, the discovery of DMM would pose a risk to site workers during the surface removal activities included in Alternative 3. The increased risk to the community during the surface removal activities would be minimal and mitigated through engineering controls or evacuations. Alternative 3 would have an impact on the environment because clearing, grubbing, and hand excavation would be required as part of the surface removal efforts.

The Public Education component of Alternative 3 would not adversely impact workers or the community.

6. Implementability – Surface removal of DMM is routinely conducted in areas of similar terrain, vegetation, and geology to that present at the Site. The Public Education Program can be easily implemented.

7. Cost – The total present value cost to perform Alternative 3 at the Osborne Pond Site is $644,000. The cost details are presented in Appendix A.

5.2.4 Alternative 4 – Subsurface Clearance of Recreational Areas with Public Education

Alternative 4 – Subsurface Clearance of Recreational Areas with Public Education is evaluated relative to the NCP criteria for the Site as follows:

1. Overall Protectiveness of Human Health and the Environment – Based on the results of the MEC investigations conducted to date at the Site, the probability of encountering DMM is considered to be low. If additional DMM are found, Alternative 4 would increase the protectiveness of human health due to the identification and removal of any DMM located from the ground surface to the instrument detection depth within the picnic areas, walking paths, and de-vegetated areas within the Former Bivouac Area where people are likely to linger. If any DMM items are found, they would be removed thereby reducing any risk to human health.

The Public education component of Alternative 4 would provide an additional level of protection of human health as discussed in Alternative 2.

2. Compliance with Federal and State Regulations – Surface and subsurface removal activities would be conducted to comply with ARARs and To Be Considered criteria. The Public Education Program would be implemented to comply with all ARARs and To Be Considered criteria as indicated in Alternative 2.

3. Long-Term Effectiveness and Permanence – Based on the historic military use of the Site as a bivouac area, it is anticipated that any potential DMM items would be located near the ground surface. Surface and subsurface removal of DMM would provide long-term effectiveness by removing any DMM found at the Site to the extent technically feasible.

As discussed in Alternative 2, the Public Education Program would provide an additional measure of long-term effectiveness and permanence after the surface and subsurface removal activities are completed.

4. Reduction of TMV of Contaminants Through Treatment – If DMM are found, surface and subsurface removal would reduce the volume of DMM at the Site.

The Public education component of Alternative 4would not provide any reduction in the volume of DMM.

5. Short-Term Effectiveness – If DMM are found, there would be a risk to site workers during the surface and subsurface removal activities included in Alternative 4. The increased risk to the community during the removal activities would be minimal and mitigated through engineering controls or evacuations. Alternative 4 would have an impact on the environment because clearing, grubbing, and excavation would be required as part of the surface and subsurface removal efforts.

The Public education component of Alternative 4 would have very little potential to adversely impact workers or the community.

6. Implementability – Surface and subsurface removal of DMM is routinely conducted in areas with similar terrain, vegetation, and geology to that present at the Site. The Public Education Program can be easily implemented.

7. Cost – The total present value cost to perform Alternative 4 at the Site is $962,000. The cost details are presented in Appendix A.

5.2.5 Alternative 5 – Complete Clearance of Former Bivouac Area with Public Education

Alternative 5 – Complete Clearance of the Former Bivouac Area with Public Education is evaluated relative to the NCP criteria for the Site as follows:

1. Overall Protectiveness of Human Health and the Environment – Based on the results of the MEC investigations conducted to date at the Site, the probability of encountering DMM is considered to be low. If additional DMM are found, Alternative 5 would increase the protectiveness of human health due to the identification and removal of any DMM located from the ground surface to the instrument detection depth within all of the undisturbed areas of the Former Bivouac Area (10.5 acres). If any DMM items are found, they would be removed thereby reducing any risk to human health.

The Public Education Program would provide an additional level of protection of human health as discussed in Alternative 2.

2. Compliance with Federal and State Regulations – Surface and subsurface removal activities would be conducted to comply with ARARs and To Be Considered criteria. The Public Education Program would be implemented to comply with all ARARs and To Be Considered criteria as indicated in Alternative 2.

3. Long-Term Effectiveness and Permanence – Based on the historic military use of the Site as a bivouac area, it is anticipated that any potential DMM items would be located near the ground surface. Surface and subsurface removal of DMM would provide long-term effectiveness by removing any DMM found at the Site to the extent technically feasible.

As discussed in Alternative 2, the Public Education Program would provide an additional measure of long-term effectiveness and permanence after the surface and subsurface removal activities are completed.

4. Reduction of TMV of Contaminants Through Treatment – If DMM are found, surface and subsurface removal would reduce the volume of DMM at the Site.

The public education component of Alternative 5 would not provide any reduction in the volume of DMM.

5. Short-Term Effectiveness – If DMM are found, there would be a risk to site workers during the surface and subsurface removal activities included in Alternative 5. The increased risk to the community during the removal activities would be minimal and mitigated through engineering controls or evacuations. Alternative 5 would have an impact on the environment because clearing, grubbing, and excavation would be required as part of the surface and subsurface removal efforts.

The public education component of Alternative 5 would have very little potential to adversely impact workers or the community.

6. Implementability – Surface and subsurface removal of DMM is routinely conducted in areas with similar terrain, vegetation, and geology to that present at the Site. The Public Education Program can be easily implemented.

7. Cost – The total present value cost to perform Alternative 5 at the Site is $2,045,000. The cost details are presented in Appendix A.

5.3 COMPARATIVE ANALYSIS OF ALTERNATIVES

Based on the detailed analysis of remedial alternatives presented in Section 5.2, the strengths and weaknesses of the remedial alternatives relative to one another are evaluated with respect to each of the NCP criteria. This comparison is presented in Table 5-1.

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TABLES

Table 1-1

Summary of Targets Investigated During the 2006 Phase I EE/CA

NATURE OF TARGET	DESCRIPTION	NUMBER	% OF TOTAL
Cultural Debris		668	82.78%
HOTROCK (Geologic Response)		41	5.08%
Quality Control (Nail)		26	3.22%
Cultural Feature		10	1.24%
Quality Assurance (USACE Item)		4	0.50%
Discarded Military Munitions	2.36-inch M6 Series Rocket Depth: 2 inches, unfired, ogive and fins rusted off, cone laying outside of body	1	0.12%
Unexploded Ordnance		0	0.00%
Munitions Debris		0	0.00%
No Contact		46	5.70%
Unresolved	Suspected culvert under several inches of water	1	0.12%
Other (HOTROCK or Cultural Debris)	Resolved, based on quality control	10	1.24%
	Total	**807**	**100.00%**

Table 2-1
Applicable and/or Relevant and Appropriate Requirements and To Be Considered Criteria

REGULATORY AUTHORITY	LOCATION CHARACTERISTIC	REQUIREMENT	STATUS	REQUIREMENT SYNOPSIS	ACTION TO BE TAKEN TO ATTAIN ARAR TO THE EXTENT PRACTICABLE
Chemical-Specific Applicable and/or Relevant and Appropriate Requirements					
No munitions constituents of concern are present at the Site; therefore, no chemical-specific ARARs and To Be Considered criteria require evaluation.					
Location-Specific Applicable and/or Relevant and Appropriate Requirements					
State	Clean Air – Dust and Odor	310 CMR 7.09	Applicable	No person responsible for an area where construction or demolition has taken place shall cause, suffer, allow, or permit particulate emissions to cause or contribute to a condition of air pollution by failure to seed, pave, cover, wet, or otherwise treat said area to prevent excessive emissions of particulate matter. No person shall cause, suffer, allow, or permit the handling, transportation, or storage of any material in a manner that result or may result in emissions which cause or contribute to a condition of air pollution.	Engineering controls will be used to minimize dust during implementation of field activities associated with earthwork.
Action-Specific Applicable and/or Relevant and Appropriate Requirements and To Be Considered Criteria					
Federal	Clean Air	Clean Air Act (CAA), Section 176(c)	To Be Considered	Section 176(c) of the CAA requires that federal agencies assure that their activities are in conformity with federally approved State Implementation Plans for geographical areas that are designated as non-attainment and maintenance areas under the CAA. "The determination of conformity shall be based on the most recent estimates of emissions, and such estimates shall be determined from the most recent population, employment, travel and congestion estimates as determined by the metropolitan planning organization or other agency authorized to make such estimates."	MMR is in a non-attainment area for ozone under the CAA, and although unanticipated, possible NOx and VOC emission generation could occur from nearby sources during remedial activities. This potential would be evaluated, and if necessary, air monitoring would be conducted prior to initiating field work.

REGULATORY AUTHORITY	LOCATION CHARACTERISTIC	REQUIREMENT	STATUS	REQUIREMENT SYNOPSIS	ACTION TO BE TAKEN TO ATTAIN ARAR TO THE EXTENT PRACTICABLE
Federal	Response Action	40 CFR 264 Subpart X – Standards for owners and operators of hazardous waste treatment, storage, and disposal facilities; Miscellaneous units	Applicable	264.601– A miscellaneous unit must be located, designed, constructed, operated, maintained, and closed in a manner that will ensure protection of human health and the environment. Subpart X outlines procedures for issuing permits to miscellaneous units that treat, store, or dispose of hazardous waste. Miscellaneous units include OB/OD units, enclosed combustion devices, carbon and catalyst regeneration units, thermal desorption units, shredders, crushers, filter presses, and geologic repositories. Subpart X does not specify minimum technology requirements or monitoring requirements for miscellaneous units. Subpart X specifies an environmental performance standard that must be met through conformance with appropriate design, operating, and monitoring requirements.	It is unlikely that UXO disposal or on-site treatment will be required as part of the proposed remedial alternatives. However, should the need for UXO disposal/treatment arise, it could require the use of technologies defined as “ miscellaneous units ” in Subpart X, including OB/OD units, shredders, crushers, etc.

Notes:

CAA	Clean Air Act
CFR	Code of Federal Regulations
CMR	Code of Massachusetts Regulations
DoD	Department of Defense
EPA	U.S. Environmental Protection Agency
HAZWOPER	Hazardous Waste Operations and Emergency Response
HTRW	Hazardous, Toxic, or Radioactive Waste
M.G.L.	Massachusetts General Law
MEC	Munitions and Explosives of Concern
NPDES	National Pollutant Discharge Elimination System
OB/OD	open burn/open detonation
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
UXO	Unexploded Ordnance
VOC	Volatile Organic Compound

Table 3-1
Screening of Detection Technologies

TECHNOLOGY	DESCRIPTION	EFFECTIVENESS		IMPLEMENTABILITY		COST		REPRESENTATIVE SYSTEMS	NOTES	RETAINED
Flux-gate magnetometers	Almost all flux-gate magnetometers measure the vertical component of the geomagnetic field along the axis of the sensor and not the total intensity of the geomagnetic field.	**Medium–High**	Has been used as the primary detector in some highly ranked systems. Has high industry familiarization. Detects ferrous objects only. Due to radiometer design, is most adept at detecting smaller, shallow items as opposed to relatively large, deeper items.	**High**	Costs, transportation, and logistics requirements are equal to or less than other systems. Is light and compact. Can be used in any traversable terrain. Is widely available from a variety of sources.	**Low**	A number of the flux-gate magnetometers have a low cost for purchase and operation compared to other detection systems. Digital units are more costly than analog units.	Schonstedt 52-CX Schonstedt 72-CX Foerster FEREX 4.032 Ebinger MAGNEX 120 LW Foerster Ferex 4.032 Vallon EL1302D1	Analog systems are not usually coregistered with navigational data. Digital output should be coregistered with navigational data.	**Yes**
Proton precession magnetometers	Proton precession magnetometers measure the total intensity of the geomagnetic field, and multiple sensors sometimes are arranged in proximity to measure horizontal and vertical gradients of the geomagnetic field.	**Medium**	Proton precession systems have similar sensitivities as flux-gate systems, but with a relatively slow sampling rate. Detects ferrous objects only.	**Low–Medium**	Systems are similar to flux-gate systems in terms of operation and support. Generally is heavier and requires more battery power than flux-gate sensor. Sampling rate is low. Can be used in any traversable terrain. Is widely available from a variety of sources.	**Medium**	Costs are comparable to flux-gate systems that acquire digital data.	Geometrics G856AX GEM Systems GSM-19T	Typically used as a base station.	No
Overhauser magnetometers	Overhauser magnetometers measure the total intensity of the geomagnetic field, and multiple sensors sometimes are arranged in proximity to measure horizontal and vertical gradients of the geomagnetic field.	**High**	Sensitivity is on the order of 0.02, which is almost equal to the most sensitive magnetic technology. Not susceptible to "heading error".	**Low–Medium**	Systems are digital, ruggedized, and weatherproof. Weighs more than most flux-gate systems. Is only available from two manufacturers, one specializing in land-based and the other marine.	**Medium–High**	Purchase and operating costs are higher than analog flux-gate systems and proton precession technology.	GEM Systems GSM-19	Primarily used for landbased and marine applications. Can be susceptible to magnetic noise.	No
Atomic-vapor magnetometers	Atomic-vapor technology is based on the theory of optical pumping and operates at the atomic level as opposed to the nuclear level (as in proton precession magnetometers).	**High**	Used in several highly ranked systems. Has high industry familiarization. Detects ferrous objects only.	**High**	Equipment is digital, ruggedized, and weatherproof. Common systems weigh more than most flux-gate systems and are affected by "heading error". Can be used in most traversable terrain. Is widely available from a variety of sources. Processing and interpretation require trained specialists. Discrimination possibilities are limited to magnetic susceptibility / magnetic moment estimates and depth estimates. Detection capabilities are influenced by iron-bearing soils.	**High**	Has high purchase cost compared to other discussed technologies. Costs less when arrays of multiple detectors are used.	Geometrics G-858 Geometrics G-822 Geometrics 880 Geometrics 882 GEM Systems GSMP-40 Scintrex Smart Mag G-tek TM4	Digital signal should be coregistered with navigational data.	**Yes**
Time-domain electromagnetic induction (TDEMI) metal detectors	TDEMI is a technology used to induce a pulsed magnetic field beneath the Earth's surface with a transmitter coil, which in turn causes a secondary magnetic field to emanate from nearby objects that have conductive properties.	**High**	Used in several highly ranked systems. Has high industry familiarization. Developed to detect small, metal objects. Detects both ferrous and nonferrous metallic objects.	**High**	Equipment is portable and ruggedized for use in various terrain and weather conditions. Some systems are heavier and consume more power than magnetometers. Typically utilize transceiver coil that is 1 m wide, but smaller versions are also available. Most commonly used instrument is widely available. Processing and interpretation are relatively straightforward. Discrimination possibilities exist for multichannel systems.	**Medium–High**	Common analog metal detectors are comparable in cost to analog flux-gate magnetometers. Digital systems are comparable in cost to Overhauser and atomic-vapor magnetometers. Costs less when arrays of multiple detectors are used.	Geonics EM61-MK1 and EM61-MK2 Geonics EM63 Zonge Nanotem G-tek TM5-EMU Vallon VMH3	Digital signal should be coregistered with navigational data. Detection depths are highly dependent on coil size and power. The implementability of the time domain electromagnetic induction metal detector is limited due to the amount of brush clearing required for proper use of this equipment. The time domain electromagnetic induction metal detector requires a clear path of at least 4' for normal configuration. In general all brush and trees 6" in diameter and smaller would be cleared. TDEMI usage will be limited to more open, accessible areas.	**Yes**

TECHNOLOGY	DESCRIPTION	EFFECTIVENESS		IMPLEMENTABILITY		COST		REPRESENTATIVE SYSTEMS	NOTES	RETAINED
Frequency domain electromagnetic induction (FDEMI) metal detectors	FDEMI sensors generate one or more defined frequencies in a continuous mode of operation.	Medium–High	Some digital units are the primary detector in highly ranked systems. Demonstrates capability for detecting small items using handheld unit. Is not optimum for detecting deeply buried objects. Has high industry familiarization. Detects both ferrous and nonferrous metallic objects.	High	Handheld detectors are generally light, compact, and ergonomic. Most are handheld. Is widely available from a variety of sources. Discrimination possibilities exist among some multichannel systems and some handheld systems.	Medium–High	Costs less when arrays of multiple detectors are used. Common handheld metal detectors are much lower cost than digital systems.	Schiebel ANPSS-12 White's All Metals Detector Fisher 1266X Geophex GEM 2 and 3, Geonics EM31 and EM34, Apex Max-Min	Analog systems are not usually coregistered with navigational data. Digital output should be coregistered with navigational data.	No
Ground penetrating radar (GPR)	GPR works by propagating electromagnetic waves into the ground via an antenna. These transmitted signals are reflected by objects and features that possess contrasts in electrical properties with the surrounding medium.	Low	Is extremely sensitive system that responds to changes in the magnetic, conductive, and dielectric properties of the subsurface. Has a very low success rate as a stand-alone MEC detection system. Detects both metallic and nonmetallic objects, but is susceptible to numerous environmental/geological conditions. Has medium industry familiarization.	Low	Man-portable systems are cumbersome to operate in varying terrain with thick vegetation. Power requirements are higher than most magnetometer and electromagnetic induction (EMI) systems. System requires skilled operators.	High	GPR systems are approximately 1.5 to two times the cost of comparable magnetometer and EMI systems.	GSSI SIR2, SIR3, SIR8, SIR10 Sensors and Software Pulse Ekko and Noggin RAMAC Mala	Data output is usually viewed in either transects or two-dimensional time slices. These have not been demonstrated to be as successful as profile outputs.	No
Sub audio magnetics (SAM)	SAM is a patented methodology by which a total field magnetic sensor is used to simultaneously acquire both magnetic and electromagnetic response of subsurface MEC.	Medium–High	Detects both ferrous and nonferrous metallic objects. Is capable tool for detection of deep MEC. Has low industry familiarization.	Low	Has high data processing requirements. Is only available from one source. Has high power requirements. Has longer than average setup times.	High	Has higher than average operating costs and very low availability.	G-tek SAM	Is not commercially available. Has no established track record.	No
Magnetometer electromagnetic detection dual sensor systems	These dual sensor systems are expected to be effective in detecting all types of MEC, as magnetometers respond to large deep ferrous targets and EMI sensors respond to nonferrous metallic targets.	High	Detects both ferrous and nonferrous metallic objects. Has medium industry familiarization. Has higher potential for discrimination.	Medium–High	Has high data processing requirements. Is available from few sources.	High	Lower costs can be obtained by using a towed array platform. Has low availability.	GEOCENTERS AETC MTADS	Is available from only a few sources.	No
Marine side scan sonar	Side-scan sonar technology uses acoustic (i.e., sound) waves to locate objects and record water bottom structure in a swath on one or both sides of its sensors.	Low	Visualizes shapes of both metallic and nonmetallic objects. Only detects items on surface of water body floor. Has low industry familiarization.	Medium	Requires trained operator, experienced field crew; calm water may be needed. Vegetation can hinder acoustic signal propagation.	High	High for marine investigations.	Klein 5500, EdgeTech DF-1000, Triton Elics Sonar Suite, GeoAcoustics, Fishers SSS-100K/600K, Marin Sonic Technologies	Few have applied this technology to the MEC problem.	No
Airborne multispectral/hyperspectral imagery	This airborne method utilizes unique spectral signatures produced by an item to determine the item composition and size. Multispectral techniques can be used since they provide more information than images from common broadband cameras.	Low	Detects both metallic and nonmetallic objects. Only detects largest MEC. Requires line of sight. Has low industry familiarization. Effectiveness increases when used for wide area assessment (WAA) in conjunction with other airborne technologies.	Low	Requires aircraft and an experienced pilot. Also requires substantial data processing and management. Is available from few sources.	High	Requires aircraft operation and has high maintenance and data processing costs.	There are many multi-/hyperspectral imagery providers	Few have applied these technologies to the MEC problem.	No
Airborne synthetic aperture radar (SAR)	Airborne SAR is a technology applicable to the detection of MEC via airborne data acquisition platforms. Typical radar measures the strength and roundtrip time of the microwave signals that are emitted by a radar antenna and reflected off a distant surface or object.	Low	Detects both metallic and nonmetallic objects. Only detects largest MEC. Requires line of sight. Has medium industry familiarization. Effectiveness increases when used for WAA in conjunction with other airborne technologies.	Low	Requires aircraft platform, increased power, and robust data recording systems. Also requires substantial data processing and management. Is available from few sources.	High	Requires aircraft operation and has high maintenance and data processing costs.	--	Few have applied these technologies to the MEC problem.	No

TECHNOLOGY	DESCRIPTION	EFFECTIVENESS		IMPLEMENTABILITY		COST		REPRESENTATIVE SYSTEMS	NOTES	RETAINED
Airborne laser and infrared (IR) sensors	IR and laser sensor technologies can be used to identify objects by measuring their thermal energy signatures. MEC on or near the soil surface may possess different heat capacities or heat transfer properties than the surrounding soil, and this temperature difference theoretically can be detected and used to identify MEC.	**Low**	Detects both metallic and nonmetallic objects. Has low industry familiarization. Effectiveness increases when used for WAA in conjunction with other airborne technologies.	**Low**	Requires aircraft and an experienced pilot. Also requires substantial data processing and management. Is available from few sources.	**High**	Requires aircraft operation and has high maintenance and data processing costs.	--	Few have applied these technologies to the MEC problem.	No

Table 3-2
Screening of Positioning Technologies

TECHNOLOGY	DESCRIPTION	EFFECTIVENESS		IMPLEMENTABILITY		COST		REPRESENTATIVE SYSTEMS	NOTES	RETAINED
Differential Global Positioning System (DGPS)	GPS is a worldwide positioning and navigation system that uses a constellation of 29 satellites orbiting the Earth. GPS uses these "man-made stars" as reference points to calculate positions on the Earth's surface. Advanced forms of GPS, like DGPS, can provide locations to centimeter accuracy.	**Medium**	Is very effective in open areas for both digital mapping and reacquiring anomalies. Is very accurate when differentially corrected. Is not effective in wooded areas or near large buildings. Commonly achieves accuracy to a few centimeters, but degrades when minimum satellites are available.	**High**	Easy to operate and set up. Requires trained operators. Is available from a number of vendors. Better systems are typically ruggedized and very durable. Some work time is lost when insufficient satellites are available.	**Low**	High-end system is available for $100–200 per day.	Leica GPS 1200 Trimble Model 5800 Thales Ashtech Series 6500	Is recommended in open areas.	**Yes**
RANGER	RANGER is a radio frequency system that uses four to eight fixed radio transponders and a mobile radio integrated to the geophysical detector system.	**Medium–High**	Can effectively survey open, vegetated, or cluttered areas with varying degrees of position accuracy. Can be set up over a 5-acre area.	**Medium**	Technique has not been successfully demonstrated on numerous MEC projects.	**Medium–High**	Purchase price is estimated to be $20,000– 30,000.	Ensco	There is only one manufacturer and limited supply at this time.	No
Robotic Total Station (RTS)	RTS is a laser-based survey station that derives its position from survey methodology and includes a servooperated mechanism that tracks a prism mounted on the geophysical sensor.	**Medium**	Is very effective in open areas for both digital mapping and reacquiring anomalies. Is effective near buildings and sparse trees. Commonly achieves accuracy to a few centimeters.	**Medium**	Easy to operate. Requires existing control.	**Low**	System is available for $150–200 per day.	Leica TRS 1100 Trimble Model 5600	Is recommended near houses or in open areas that have a high tree line.	**Yes**
Laser	The ArcSecond constellation system calculates locations by triangulating the signals of stationary lasers placed on the edge of a grid. The system uses four laser transmitters, although only two are required to calculate the position in three dimensions.	**High**	Is very effective in wooded areas. Can be used in open areas, though is limited due to range of transmitters. Is extremely accurate positioning system. Commonly achieves accuracy to a few centimeters.	**Low**	Technology has a time-consuming setup due to numerous parts and connections. Equipment is not ruggedized.	**Medium**	System is available for less than $200 per day.	ArcSecond "In-door GPS" (Constellation)	Is recommended in wooded areas.	No
Fiducial method	The fiducial method consists of digitally marking a data string (data set) with an indicator of a known position. Typically, lines or markers are placed on the ground at known positions (e.g., 25 feet).	**Medium**	Has medium effectiveness when performed by experienced personnel. Has low effectiveness when used by inexperienced personnel. Commonly achieves accuracy of 15–30 cm.	**Low**	Is difficult to use and requires constant pace, detailed field notes, and elaborate setup.	**Low**	Minimal direct costs are associated with this method. Is similar to fiducial method.	Not available (N/A)	Requires very capable operators. Is a useful method if digital positioning systems are unavailable.	**Yes**
Odometer method	This method utilizes an odometer, which physically measures the distance traveled.	**Medium**	Has medium effectiveness when performed by experienced personnel. Has low effectiveness when used by inexperienced personnel. Commonly achieves accuracy of 15–30 cm.	**Low**	Setup and operation are affected by terrain/environment. Requires detailed field notes and lengthy setup. Is similar to fiducial method.	**Low**	Very little costs are associated with this technology.	N/A	--	No

Acoustic	This navigation system utilizes ultrasonic techniques to determine the location of a geophysical instrument each second. It consists of three basic elements, a data pack, up to 15 stationary receivers, and a master control center.	**Medium–Low**	Is not very efficient in open areas due to substantial calibration setup time. Is reasonably effective in wooded areas, although less accurate than other methods. Commonly achieves accuracy of 10–30 cm.	**Low**	This technology is difficult to set up, and there is minimal available support. Is negatively affected by certain aspects of environment.	**Medium**	System is available for around $200 per day.	USRADS	Has been used extensively in wooded areas with success.	**Yes**
Inertial navigation	An inertial navigation system measures the acceleration of an object in all three directions and calculates the location relative to a starting point. The starting point is input and periodically refreshed using another navigation system, typically DGPS.	**Low–Medium**	Is very time consuming with below average accuracy. Accuracy of 4–6 cm (open area) is commonly achieved shortly after refreshing baseline data, but degrades quickly with time. Required frequency of refreshing baseline significantly reduces production rates.	**Low**	Is difficult to operate and has limited support.	**High**	Is expensive to purchase or rent.	Ranger	This technology is still under development.	No

Table 3-3
Screening of Recovery Technologies

TECHNOLOGY	DESCRIPTION	EFFECTIVENESS		IMPLEMENTABILITY		COST		REPRESENTATIVE SYSTEMS	NOTES	RETAINED
Hand excavation	Hand excavation consists of digging individual anomalies using commonly available hand tools.	**Medium**	It can be very thorough and provides good data on any munitions collected.	**High**	Can be accomplished in almost any terrain and climate. Is limited only by the number of people available.	**Average**	Is the standard by which all others are measured.	Probe, trowel, shovel, pick axe.	Are locally available and easily replaced tools.	**Yes**
Mechanized removal of individual anomalies	This method uses commonly available mechanical excavating equipment, such as a backhoe or excavator.	**Medium**	Used in conjunction with hand excavation when soil is so hard it causes time delays. Method works well for the excavation of single anomalies or larger areas of heavy ferrous metal concentration.	**High**	Equipment can be rented almost anywhere and is easy to operate. Allows excavation of anomalies in hard soil and clearing of large areas with substantial metal concentration.	**Low**	In hard soil this method has a lower cost than that of having the single anomalies hand excavated.	Tracked mini-excavator, bull dozers, loaders, etc.; multiple manufacturers	Equipment is easy to rent and to operate.	**Yes**
Mass excavation and sifting	Armored excavation and transportation is earth moving equipment that has been armored to protect the operator and equipment from unintentional detonation.	**High**	Process works very well in areas of heavy concentration of UXO or DMM. Can separate several different sizes of material, allowing for large quantities soil to be returned with minimal screening for MEC.	**Medium**	Earth moving equipment is readily available. However, armoring is not as widely available. Equipment is harder to maintain and may require trained heavy equipment operators. Not feasible for large explosively configured munitions.	**High**	Earth moving equipment is expensive to rent and insure and has the added expense of high maintenance cost.	Earth moving equipment: Many brands of heavy earth moving equipment, including excavators, off-road dump trucks, and front-end loaders, are available. Sifting equipment: Trommel, shaker, rotary screen from varying manufacturers.	Can be rented, armor installed, and delivered almost anywhere. Significant maintenance costs.	No
Mechanized soil processing	Once the soil has been excavated and transported to the processing area, it is then processed through a series of screening devices and conveyors to produce segregated soils of different grain sizes.	**High**	Mechanized processing systems are a proven technology for removing MEC and other solid materials from soil.	**High**	Equipment and references for planning and operations are readily available.	**Medium–High**	Acquisition and operation of these systems is initially expensive, though savings may be realized for large economy of scale efforts.	A wide variety of equipment and suppliers are available for shaker and trommel systems.	Use of magnetic technology (rollers) can augment capabilities for some MEC applications.	No
Magnetically assisted recovery	The most promising application of magnetic technology is in scrap and soil processing.	**Low**	Primarily used in conjunction with mass excavation and sifting operations. Can help remove metal from separated soils, but does not work well enough to eliminate the need to inspect the smaller size soil spoils. Magnetic systems are also potentially useful to help with surface clearance of fragmentation and surface debris.	**High**	Magnetic rollers are easily obtained from the sifting equipment distributors and are designed to work with their equipment.	**Low**	This method adds very little cost to the already expensive sifting operation.	Magnetic rollers or magnetic pick-ups are available from many manufacturers of the sifting equipment noted above.	Installed by sifting equipment owners.	No

Remotely operated removal equipment	Remotely operated equipment is excavating equipment that has had additional control equipment added that allows the equipment to be operated remotely.	**Low**	Remotely operated equipment reduces productivity and capability of the equipment. Method is not widely used and is not yet proven to be an efficient means of MEC recovery.	**Low**	Uses earth moving equipment, both mini excavator type and heavier off-road earth moving equipment. Machinery is rigged with hydraulic or electrical controls to be operated remotely.	**High**	Has a combined cost of the base equipment plus the remote operating equipment and an operator. Remote operation protects the operator, but can create high equipment damage costs.	Many tracked excavators, dozers, loaders, and other equipment types have been outfitted with robotic remote controls.	EOD robots are almost exclusively used for military and law enforcement reconnaissance and rendersafe operations. They have been tested for MEC applications.	No

Table 3-4
Screening of Disposal Technologies

TECHNOLOGY	DESCRIPTION	EFFECTIVENESS		IMPLEMENTABILITY		COST		REPRESENTATIVE SYSTEMS	NOTES	RETAINED
Blown-in-Place (BIP)	BIP is the destruction of MEC for which the risk of movement beyond the immediate vicinity of discovery is not considered acceptable. Normally, this is accomplished by placing an explosive charge alongside the item.	**High**	Munitions are individually or collectively destroyed with the destruction verified (QC/QA).	**High**	Uses field-proven techniques, transportable tools, and equipment and is suited to most environments. Public exposure can limit viability of this option. ECs can further improve implementation.	**Low**	Is manpower intensive. Costs increase in areas of higher population densities or where public access must be monitored/ controlled.	Electric demolition procedures; nonelectric demolition procedures	Disposition of resultant waste streams must be addressed in planning. Any stream produced by BIP is not contained. Increased regulatory involvement may result in higher life cycle cost for waste (for characterization, treatment, and disposal) than for technologies that do contain the waste streams. The Department of Defense (DoD) has committed to reducing its reliance on the use of open detonation.	**Yes**
Consolidate and blow detonations	Consolidate and blow detonations are defined as the collection, configuration, and subsequent destruction by explosive detonation of MEC for which the risk of movement has been determined to be acceptable either within a current working sector or at an established demolition ground.	**High**	Techniques recently developed and refined in Iraq are providing documented successes. Use of donor munitions is also proving effective. Is limited in use to munitions that are "safe to move".	**Medium–High**	Generally employs same techniques, tools, and equipment as BIP. Requires larger area and greater controls. Most ECs not completely effective/ applicable for these operations.	**Medium**	Is manpower intensive; may require material handling equipment for large-scale operations.	Electric demolition procedures; nonelectric demolition procedures; forklifts and cranes	Disposition of resultant waste streams must be addressed. Increased areas require additional access and safety considerations. Waste streams produced by consolidate detonations are not contained. As regulatory agencies become more involved in munitions responses, this may yield higher life cycle costs for waste (for characterization, treatment, and disposal) than for technologies that do contain waste streams. This could be of even greater concern in consolidate and blow operations where there will be more residual generated and, thus, potentially greater concentrations of regulated analytes.	No
Laser initiation	Portable (vehicle-mounted) lasers are used from a safe distance to heat MEC laying on the surface, resulting in high- or low-order detonation of the munitions.	**Low–Medium**	Is still in development, though currently is deployed in Iraq for testing. Tests show positive results for 81 mm and smaller munitions, with reported success on munitions up to 155 mm. Produces low-order type effect; subsequent debris still requires disposition.	**Low–Medium**	MEC targets must be exposed / on surface for track by directed beam. GATOR Laser System (diode laser neutralization via fiber-optic delivered energy) does not require line-of-sight within approximately 100 m. GATOR system does require approach and placement of fiber-optic cable at appropriate position of MEC. Laser systems are still addressing power, configuration, transportability, and logistics issues.	**Low–Medium**	Requires greatly reduced manpower. Has added equipment, transportability, and logistics concerns. No explosives are required by the system.	ZEUS-HLONS GATOR LASER	Offers added safety through significant standoff (up to 300 m). (Note: Acceptable safety standoffs must be evaluated for specific MEC and scenarios). ZEUS prototype was deployed/employed in Afghanistan (2003). Waste streams produced by laser initiation are not contained. As regulatory agencies become more involved in munitions responses, this may yield higher life cycle costs for waste (for characterization, treatment, and disposal) than technologies that do contain waste streams. This may be of even more concern with laser initiated detonation/deflagration, as residual contamination may be higher than with traditional BIP. Low-order detonations could yield greater environmental contamination than successful BIP operations.	No
Contained detonation chambers - stationary	Contained detonation chambers involve destruction of certain types of munitions in a chamber, vessel, or facility designed and constructed specifically for the purpose of containing blast and fragments. Contained detonation chambers can only be employed for munitions for which the risk of movement has been determined acceptable.	**High**	Chambers successfully contain hazardous components. Current literature reviewed shows containment up to 40 pounds (lb) (net explosives weight [NEW]).	**Low–Medium**	Stationary facilities typically must meet regulatory and construction standard for permanent/ semipermanent waste disposal facilities. Service life and maintenance are issues. Such facilities are not commonly used in support of munitions responses. Produces additional hazardous waste streams. Contained detonation chamber is presently located at MMR.	**High**	Sitting and construction required. Low feed rates lead more hours on site. Has significant requirements for maintenance of system.	Typically is designed on case-by-case basis.	System cleaning and maintenance usually require personal protective equipment (PPE) and worker training. Have probable permitting issues with employment of technology.	**Yes**
Contained detonation chambers - mobile	Contained detonation chambers involve destruction of certain munitions in a chamber, vessel, or facility designed and constructed specifically for the purpose of containing blast and fragments. Contained detonation chambers can only be employed for munitions for which the risk of movement has been determined acceptable for transport over public highways.	**High**	Chambers successfully contain hazardous components. Current literature reviewed shows containment up to 40 lb NEW.	**Medium–High**	Designed to be deployed at the MRS. Has greatly reduced footprint compared to stationary facilities. Service life and maintenance are issues. Requires additional handling of MEC. Produces additional hazardous waste streams.	**Medium–High**	Possible construction required (e.g., berms, pads). Low feed rates leads to more hours on site. Significant requirements for maintenance of system.	Transportable Detonation Chambers (T-10) Kobe Blast Chamber	System cleaning and maintenance usually require PPE and worker training. Have possible permitting issues with employment of technology (on other than CERCLA/FUDS sites). The fact that the waste stream is contained and is more easily dealt with (even when hazardous) is an advantage in terms of public perception and in life cycle cost.	No

TECHNOLOGY	DESCRIPTION	EFFECTIVENESS		IMPLEMENTABILITY		COST		REPRESENTATIVE SYSTEMS	NOTES	RETAINED
Disassembly or Render Safe Procedures (RSPs)	Disassembly or RSPs are the procedures that enable the neutralization or disarming of mines and munitions to occur in a recognized and safe manner. RSPs are executed by explosive ordnance disposal (EOD) personnel.	**Low**	Hazardous components may remain intact after procedure. Some procedures may expose hazardous materials inadvertently or intentionally. Have lower probability of success compared to other methods. Present significant danger to personnel conducting disposal operations. DoD policy allows RSP at MRSs only in cases of extreme emergency. RSPs are not allowed for the mere purpose of rendering a munitions item acceptable to move.	**Low**	Have significant personnel exposure in implementation. Specialized tools and equipment commonly are required.	**Medium–High**	Is manpower intensive. Specialized tools and equipment are required.	Manual disassembly Mechanical disassembly Explosive de-armer Cryofracture	Procedures are not commonly applied even by authorized military EOD personnel, except in rare circumstances.	No

Table 3-5
Screening of Treatment Technologies

TECHNOLOGY	EFFECTIVENESS		IMPLEMENTABILITY		COST		REPRESENTATIVE SYSTEMS	NOTES	RETAINED
Chemical Decontamination	**Low to Medium**	Great variance in chemicals required to decontaminate various MEC (e.g., propellants, pyrotechnics, and explosives). Difficult to test for effectiveness of many methods. May generate additional waste streams (some hazardous).	**Low to Medium**	Requires containment of multiple hazardous materials (e.g., MEC and solvents). May require emissions controls. Worker training and PPE typically required.	**Medium to High**	Specialized manpower, containment requirements, additional waste stream processing	Various solvents (acetone, acids); water		**Yes**
Shredders and Crushers	**Medium**	Renders small arms, fuses and other components inoperable. Residue will typically still require additional treatment to achieve higher decontamination levels.	**Low to Medium**	Typically stationary facilities. Service life and very high maintenance are expected. Requires additional handling of MEC.	**Medium to High**	Specialized equipment and operators. High maintenance. Additional waste stream processing.	Shred Tech ST-100H Roll-Off (vehicle mounted)	Disposition of resultant waste streams must be addressed.	No
Thermal Treatment	**High**	Furnaces are designed to contain hazardous components. Methods are proven means of attaining high degrees (5X) of decontamination. Commonly used to destroy and decontaminate fuses and smaller explosive components.	**Medium**	Typically stationary facilities. Service life and maintenance are issues. Requires additional handling of MEC. Flashing furnaces have low feed rates due to safety concerns. Produces additional hazardous waste streams	**High**	Possible construction required. Low feed rates = more hours on site. Maintenance of system.	Rotary kiln incinerator Explosive waste incinerator (EWI) Transportable flashing furnace	System cleaning and maintenance usually requires PPE and worker training. May require permit to deploy technology.	**Yes**
Recycling	**High**	Very effective for MD and non-MEC-related scrap. Not appropriate for munitions constituents that still pose an explosive hazard.	**High**	Easily implemented if there is a local metal recycler.	**Low to Medium**				**Yes**

Table 3-6

Retained Technologies

MEC DETECTION		MEC Recovery	MEC DISPOSAL	
Geophysical Detection	**Positioning**	**Removal**	**Disposal**	**Treatment**
• Mag and Dig (M&D) • Digital Geophysical Mapping (DGM)	• Robotic Total Station (with DGM) • Fiducial Method (with DGM) • Acoustic Method (with DGM) • Differential Global Positioning System (DGPS)	• Hand excavation • Mechanical excavation to within 12 inches of anomalies, followed by hand excavation (only for anomalies deeper than 12 inches)	• A combination of the following methods, based on munitions and explosives of concern (MEC) item evaluation in the field by qualified UXO technicians: - Blown-in-Place (BIP) - Contained Detonation Chamber (CDC)	• Munitions debris (MD) and non-MEC related material recovered from MEC disposal that is certified as safe will be sent to an approved metals recycler. • Munitions constituents (MC) from MEC disposal will be addressed as appropriate, and treated if necessary, using one of the following methods: - Chemical decontamination - Thermal treatment

Table 4-1
Summary of Remedial Alternatives

Alternative No.	General Remedial Action	Processes	Access Control/ Public Education	MEC Detection: Detection	MEC Detection: Positioning	MEC Recovery	MEC Disposal: Disposal	MEC Disposal: Waste Stream Treatment
1	No Action	NA	NA	NA	NA	NA	NA	NA
2	Public Education	Access Control, Public Education Program	Signage, Brochures, Classroom education	NA	NA	NA	NA	NA
3	Limited Subsurface Removal	Detection, Recovery, Disposal	NA	Visual and Analog (M&D)	RTS, Fiducial Method, or Acoustic Method (with DGM) or DGPS	Hand excavation	BIP and CDC	Recycling or Treatment
	Public Education	Access Control, Public Education Program	Signage, Brochures, Classroom education	NA	NA	NA	NA	NA
4	Removal to detection depth	Detection, Recovery, Disposal	NA	Digital (DGM) or Analog (M&D)	RTS, Fiducial Method, or Acoustic Method (with DGM) or DGPS	Mechanical excavation to within 12 inches of anomalies, followed by hand excavation	BIP and CDC	Recycling or Treatment
	Public Education	Access Control, Public Education Program	Signage, Brochures, Classroom education	NA	NA	NA	NA	NA
5	Removal to detection depth	Detection, Recovery, Disposal	NA	Digital (DGM) or Analog (M&D)	RTS, Fiducial Method, or Acoustic Method (with DGM) or DGPS	Mechanical excavation to within 12 inches of anomalies, followed by hand excavation	BIP and CDC	Recycling or Treatment
	Public Education	Access Control, Public Education Program	Signage, Brochures, Classroom education	NA	NA	NA	NA	NA

Notes: BIP — Blown-in-Place
CDC — Contained Detonation Chamber
DGM — Digital Geophysical Mapping
DGPS — Differential Global Positioning System
M&D — Mag and Dig
NA — Not Applicable

Table 5-1
Comparative Analysis of Remedial Alternatives

Alternative		Overall Protectiveness of Human Health and the Environment	Compliance with ARARs and To Be Considered Criteria	Long-Term Effectiveness and Permanence	Reduction of TMV of Contaminants Through Treatment	Short-Term Effectiveness	Implementability	Cost
1	No Action	Not protective	Compliant	Potential risks remain. RAOs not achieved.	No reduction	No impact to community or workers since no action will be taken.	Most implementable	$0
2	Public Education	Protective	Compliant	Potential risks may remain but are mitigated by Public Education. RAOs may not be achieved.	No reduction	No impact to community or workers.	Easily implementable	$397,000
3	Limited Subsurface Clearance of Recreational Areas with Public Education	Protective	Compliant	Potential risks may be reduced by surface removal and mitigated by Public Education. RAOs will be achieved.	Reduction, if DMM are present	Significant impact on workers. Limited impact on community. Impact on the environment due to clearing and vegetation removal.	Implementable	$644,000
4	Subsurface Clearance of Recreational Areas with Public Education	Protective	Compliant	Potential risks may be eliminated by surface and subsurface removal. RAOs will be achieved.	Reduction, if DMM are present at surface and subsurface	Significant impact on workers. Limited impact on community. Impact on the environment due to clearing and vegetation removal.	Implementable	$962,000
5	Complete Clearance of the Former Bivouac Area with Public Education	Protective	Compliant	Potential risks may be eliminated by surface and subsurface removal. RAOs will be achieved.	Greatest reduction, if DMM are present at surface and subsurface	Significant impact on workers. Limited impact on community. Impact on the environment due to clearing and vegetation removal.	Implementable	$2,045,000

Notes:

ARARs	Applicable or Relevant and Appropriate Requirements
RAOs	Remedial Action Objectives
TMV	Toxicity, Mobility, or Volume
DMM	Discarded Military Munitions

FIGURES

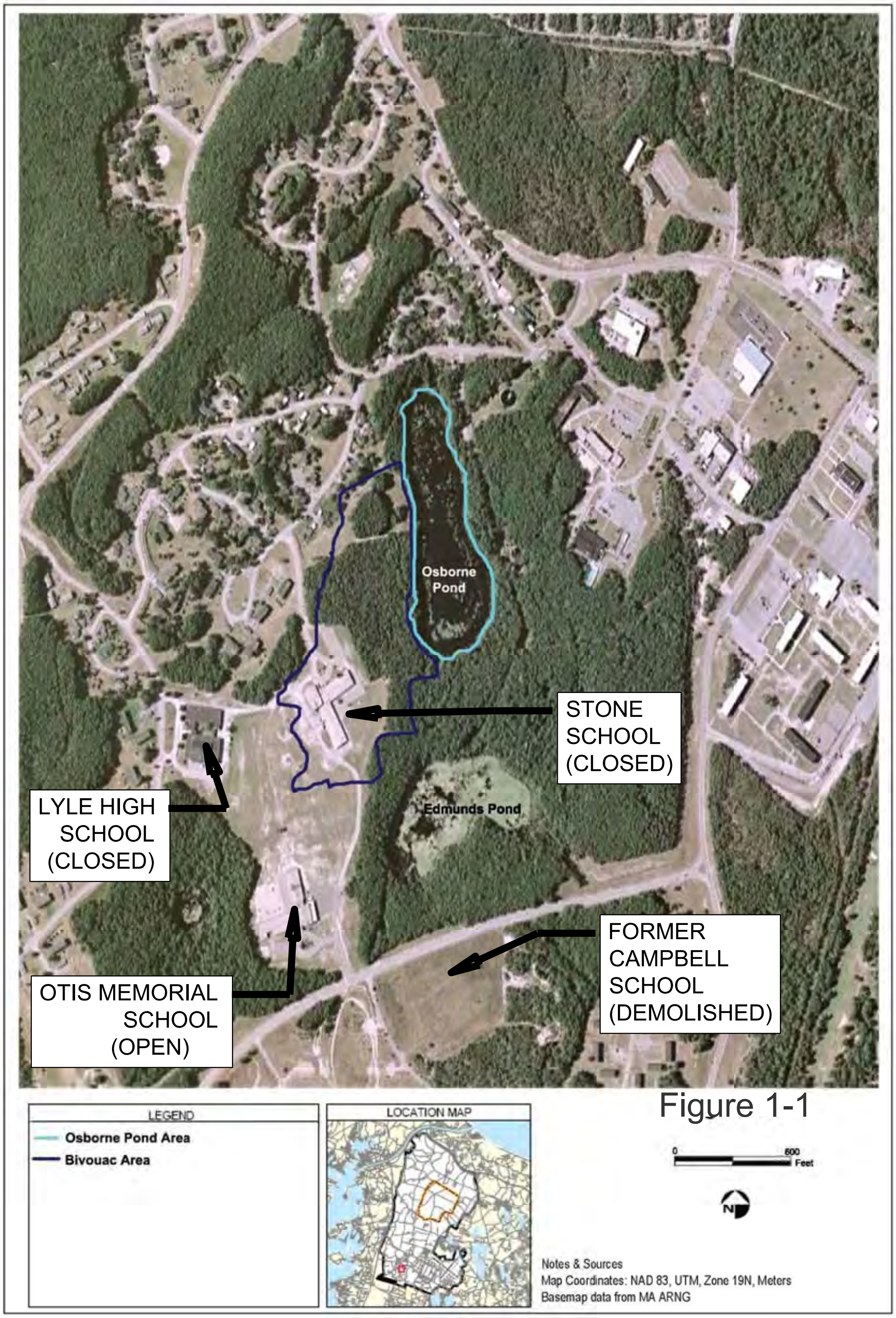


Figure 1-1

Site Map

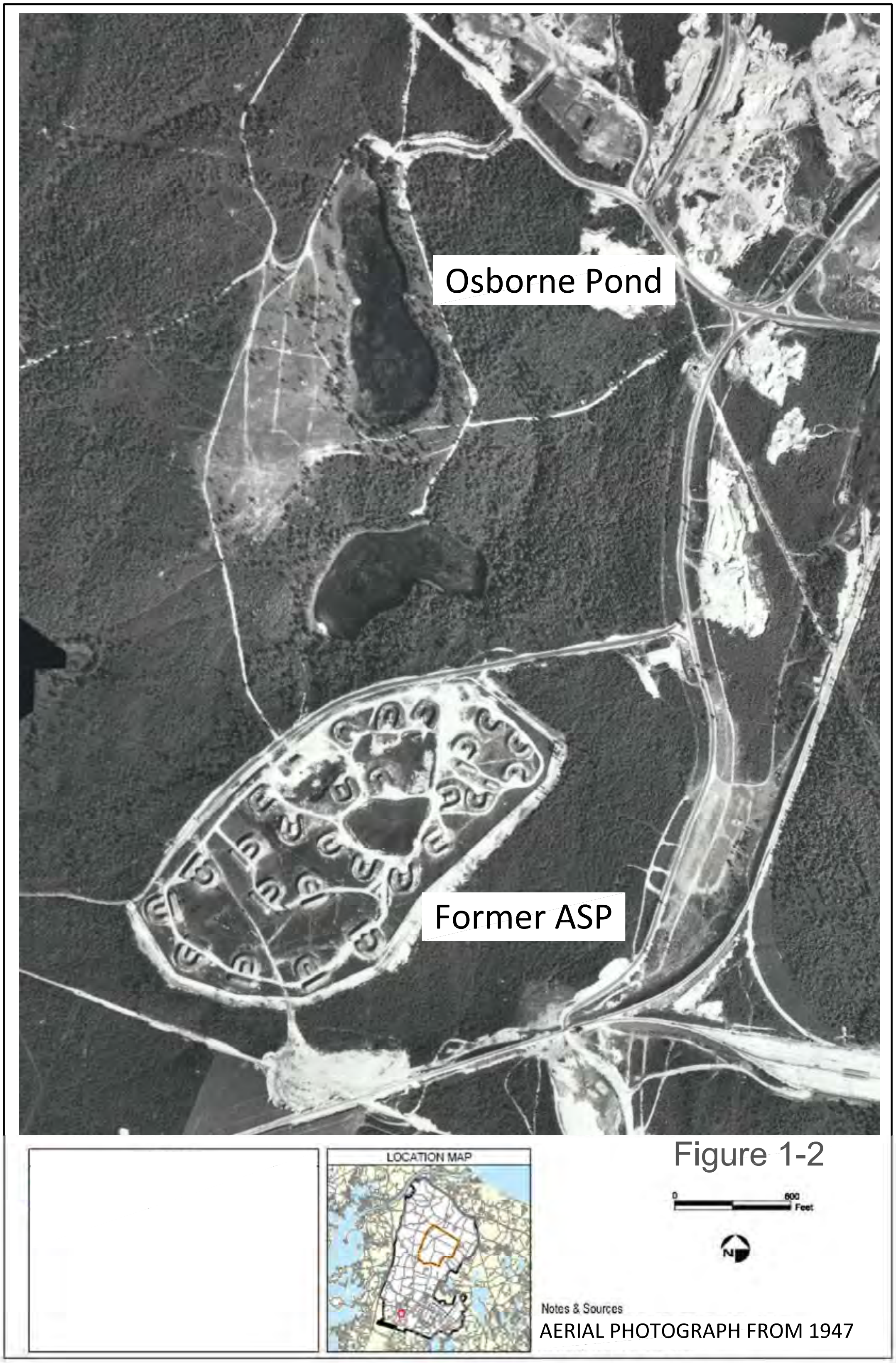


Figure 1-2

Osborne Pond FUDS
and Former ASP

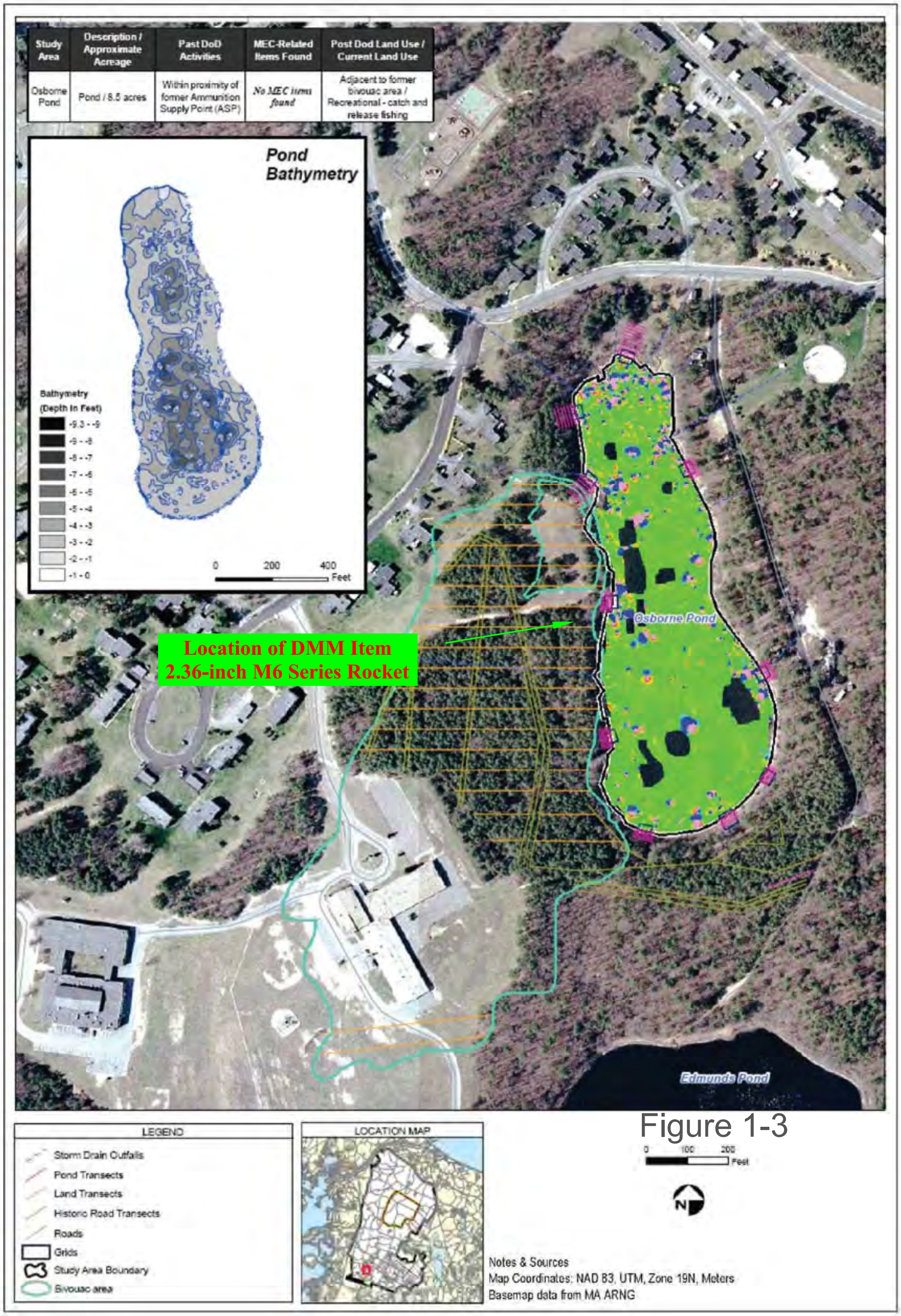


Figure 1-3

Summary of MEC Investigations

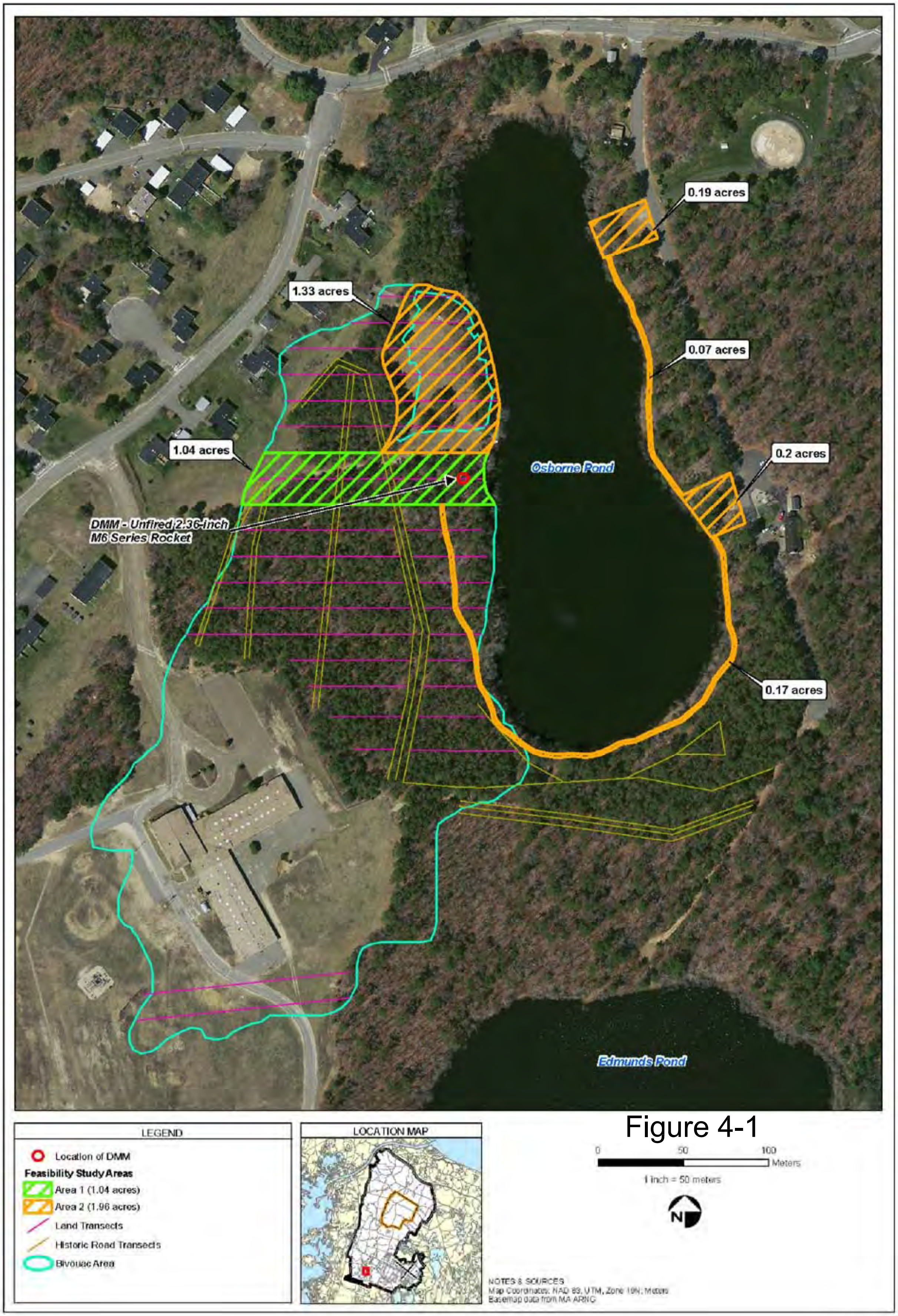


Figure 4-1

Feasibility Study Areas

APPENDIX A

Cost Estimates

COST ESTIMATE SUMMARY

The costs provided in this FS report are based upon the cost estimates presented in the EE/CA (ZAPATAENGINEERING, 2007). The rates used in the EE/CA were inflated to Year 2012 using an inflation rate of 2.35 percent; the average Consumer Price Index from 2007 to 2012 (www.bls.gov, April 2012). A discount rate of 2.0 percent was used for present value calculations ("OMB Circular No. A-94, Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs, Appendix C", January 2012). Contingencies and Professional/Technical Services were selected in accordance with "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA, July 2000".

Cost assumptions from the EE/CA (Appendix E, Cost Breakdowns and Assumptions) were used and modified to match the current conceptual design of the alternatives. The acreage for Alternatives 3 and 4 was decreased from 5.9 acres to 3 acres. The quantities related to the field work and applicable lump sum items were reduced accordingly; no changes were made to quantities related to design, implementation, oversight, contract management, and reporting. The costs for Alternative 5 were developed using the costs from Alternative 4 and scaling the quantities related to field work and applicable lump sum items to the acreage of Alternative 5 (10.5 acres).

Table A-1
Alternative 1 – No Action

CAPITAL COST				
Item	**Unit**	**Rate**	**Quantity**	**Cost**
No work associated with this Alternative				
			Total Capital Cost =	**$0**
ANNUAL O&M COST				
Item	**Unit**	**Rate**	**Quantity**	**Cost**
No Annual O&M associated with this Alternative				
			Total Annual O&M Cost =	**$0**
PERIODIC COST				
Item	**Unit**	**Rate**	**Quantity**	**Cost**
Five Year Review (Year 5, 10, 15, 20, 25, 30)	Event	$57,802	0	$0

PRESENT VALUE ANALYSIS					
Cost Type	**Year**	**Cost/Year**	**Total Cost/Year**	**Discount Factor (%)**	**Present Value**
Capital Cost	0	$0	$0	1.000	$0
Annual O&M Cost	1 - 30	$0	$0	20.383	$0
Periodic Cost	5	$0	$0	0.924	$0
Periodic Cost	10	$0	$0	0.804	$0
Periodic Cost	15	$0	$0	0.696	$0
Periodic Cost	20	$0	$0	0.587	$0
Periodic Cost	25	$0	$0	0.514	$0
Periodic Cost	30	$0	$0	0.450	$0

Total Present Value of Alternative 1 = $0

Table A-2
Alternative 2 – Land Use Controls

CAPITAL COST				
Item	**Unit**	**Rate**	**Quantity**	**Cost**
Project Design (WP, SSHP, Road Closure Plan)	Man-hours	$75	56	$4,204
Project Implementation	Man-hours	$75	40	$3,003
Project Oversight	Man-hours	$121	8	$967
Contract Management	Man-hours	$90	8	$723
UXO Safety Officer (4% differential)	Man-hours	$63	24	$1,506
UXO Safety Officer (no differential)	Man-hours	$60	40	$2,413
Airfare	Round trip	$814	3	$2,443
Rental Vehicles	Day	$73	7	$509
Hotel Stay (Peak Season)	Day	$152	8	$1,220
Per Diem	Day	$51	9.5	$485
Vehicle Fuel	Gallon	$3	10	$33
Equipment, Supplies, and Storage Magazine	Lump sum	$7,234	1	$7,234
Land Use Control Implementation Plan	Lump sum	$10,000	1	$10,000
Educational Materials	Lump sum	$10,000	1	$10,000
Classroom Education at On-Base Schools	Lump sum	$6,000	1	$6,000
Information Web-Site	Lump sum	$5,000	1	$5,000
Custom Warning Signs	Each	$71	30	$2,144
Subtotal =				$57,885
Contingency (15% Scope + 15% Bid) =	30%			$17,366
Subtotal =				$75,251
Project Management =	8%			$6,020
Remedial Design =	15%			$11,288
Construction Management =	10%			$7,525
			Total Capital Cost =	**$100,083**

ANNUAL O&M COST				
Item	**Unit**	**Rate**	**Quantity**	**Cost**
Annual Sign Maintenance/Education for 30 Years	Each	$2,000	1	$2,000
			Total Annual O&M Cost =	**$2,000**

PERIODIC COST				
Item	**Unit**	**Rate**	**Quantity**	**Cost**
Five Year Review (Year 5, 10, 15, 20, 25, 30)	Event	$57,802	1	$57,802

PRESENT VALUE ANALYSIS					
Cost Type	**Year**	**Cost/Year**	**Total Cost/Year**	**Discount Factor (%)**	**Present Value**
Capital Cost	0	$100,083	$100,083	1.000	$100,083
Annual O&M Cost	1 - 30	$2,000	$2,000	20.383	$40,766
Periodic Cost	5	$57,802	$57,802	0.924	$53,392
Periodic Cost	10	$57,802	$57,802	0.804	$46,498
Periodic Cost	15	$57,802	$57,802	0.696	$40,203
Periodic Cost	20	$57,802	$57,802	0.587	$33,926
Periodic Cost	25	$57,802	$57,802	0.514	$29,695
Periodic Cost	30	$57,802	$57,802	0.450	$25,991

Total Present Value of Alternative 2 = $370,555

Table A-3
Alternative 3 – Surface Removal with Land Use Controls

CAPITAL COST				
Item	**Unit**	**Rate**	**Quantity**	**Cost**
Project Design (WP, SSHP, Road Closure Plan)	Man-hours	$75	420	$31,533
Project Implementation	Man-hours	$75	112	$8,409
Project Oversight	Man-hours	$121	80	$9,667
Contract Management	Man-hours	$90	16	$1,446
UXO Safety Officer (8% differential)	Man-hours	$65	4	$261
UXO Safety Officer (4% differential)	Man-hours	$63	24	$1,506
UXO Safety Officer (no differential)	Man-hours	$60	86	$5,189
Senior UXO Supervisor (8% differential)	Man-hours	$88	0	$0
Senior UXO Supervisor (4% differential)	Man-hours	$84	0	$0
Senior UXO Supervisor (no differential)	Man-hours	$81	90	$7,297
1 - UXO Supervisor (8% differential)	Man-hours	$68	36	$2,453
1 - UXO Supervisor (4% differential)	Man-hours	$66	0	$0
1 - UXO Supervisor (no differential)	Man-hours	$63	30	$1,893
4 - UXO Technician II (8% differential)	Man-hours	$53	180	$9,536
4 - UXO Technician II (4% differential)	Man-hours	$51	208	$10,613
4 - UXO Technician II (no differential)	Man-hours	$49	84	$4,121
Security Guard (Nightime Magazine Security)	Man-hours	$20	108	$2,192
Airfare	Round trip	$814	14	$11,403
Rental Vehicles	Day	$73	68	$4,949
Gator Support Vehicle	Month	$836	2	$1,671
Gator Support Vehicle Pickup and Delivery	Each	$79	2	$158
Hotel Stay (Peak Season)	Day	$152	108	$16,465
Per Diem	Day	$51	123.5	$6,300
One-Time Explosives Delivery	Each	$1,051	1	$1,051
Brush Clearing Contractor	Grid	$525	25	$13,137
Surveyor	Day	$1,682	21	$35,312

Vehicle Fuel	Gallon	$3	930	$3,108
Equipment, Supplies, and Storage Magazine	Lump sum	$7,234	1	$7,234
Road Closures	Each	$0.00	0	$0
Project Report	Man-hours	$75	175	$13,139
Project Report Review	Man-hours	$85	36	$3,068
Subtotal =				$213,110
Contingency (15% Scope + 15% Bid) =	30%			$63,933
Subtotal =				$277,044
Project Management =	6%			$16,623
Remedial Design =	12%			$33,245
Construction Management =	8%			$22,163
			Total Capital Cost =	**$349,075**
ANNUAL O&M COST				
Item	**Unit**	**Rate**	**Quantity**	**Cost**
Annual Sign Maintenance/Education for 30 Years	Each	$2,000	1	$2,000
			Total Annual O&M Cost =	**$2,000**
PERIODIC COST				
Item	**Unit**	**Rate**	**Quantity**	**Cost**
Land Use Controls from Alternative 2	LS	$100,083	1	$100,083
Five Year Review (Year 5, 10, 15, 20, 25, 30)	Event	$57,802	1	$57,802
			Total Periodic Cost =	**$157,885**

PRESENT VALUE ANALYSIS					
Cost Type	**Year**	**Cost/Year**	**Total Cost/Year**	**Discount Factor (%)**	**Present Value**
Capital Cost	0	$349,075	$349,075	1.000	$349,075
Annual O&M Cost	1 - 30	$2,000	$2,000	20.383	$40,766
Periodic Cost	0	$100,083	$100,083	1.000	$100,083
Periodic Cost	5	$57,802	$57,802	0.924	$53,392
Periodic Cost	10	$57,802	$57,802	0.804	$46,498
Periodic Cost	15	$57,802	$57,802	0.696	$40,203
Periodic Cost	20	$57,802	$57,802	0.587	$33,926
Periodic Cost	25	$57,802	$57,802	0.514	$29,695
Periodic Cost	30	$57,802	$57,802	0.450	$25,991

Total Present Value of Alternative 3 = $719,630

Table A-4
Alternative 4 – Removal to Detectable Depth with Land Use Controls

CAPITAL COST				
Item	**Unit**	**Rate**	**Quantity**	**Cost**
Project Design (WP, SSHP, Road Closure Plan)	Man-hours	$75	475	$35,663
Project Implementation	Man-hours	$75	268	$20,121
Project Oversight	Man-hours	$121	84	$10,150
Contract Management	Man-hours	$90	16	$1,446
Digital Geophysical Mapping	Lump sum	$94,963	1	$94,963
Sr Geophysicist (GPO & Geophysical Data Interpretation)	Man-hours	$108	226	$24,473
UXO Safety Officer (8% differential)	Man-hours	$65	19	$1,238
UXO Safety Officer (4% differential)	Man-hours	$63	114	$7,154
UXO Safety Officer (no differential)	Man-hours	$60	151	$9,111
Senior UXO Supervisor (8% differential)	Man-hours	$88	0	$0
Senior UXO Supervisor (4% differential)	Man-hours	$84	0	$0
Senior UXO Supervisor (no differential)	Man-hours	$81	378	$30,648
1 - UXO Supervisor (8% differential)	Man-hours	$68	152	$10,358
1 - UXO Supervisor (4% differential)	Man-hours	$66	0	$0
1 - UXO Supervisor (no differential)	Man-hours	$63	54	$3,407
4 - UXO Technician II (8% differential)	Man-hours	$53	608	$32,211
4 - UXO Technician II (4% differential)	Man-hours	$51	388	$19,797
4 - UXO Technician II (no differential)	Man-hours	$49	168	$8,242
4 - UXO Technician II (4% differential) (reacq)	Man-hours	$51	560	$28,573
4 - UXO Technician II (no differential) (reacq)	Man-hours	$49	64	$3,140
Security Guard (Nightime Magazine Security)	Man-hours	$20	408	$8,280
Airfare	Round trip	$814	15	$12,217
Rental Vehicles	Day	$73	259	$18,849
Fuel	gal	$3	5610	$18,749
Hotel Stay (Peak Season)	Day	$152	399	$60,830
Per Diem	Day	$51	413.5	$21,095
One-Time Explosives Delivery	Each	$1,051	1	$1,051
Brush Clearing Contractor	Grid	$525	25	$13,137
Surveyor	Day	$1,682	21	$35,312
Equipment, Supplies and Storage Magazine	Lump sum	$7,388	1	$7,388
Porta-Johns	Month	$95	3.5	$331
Gator Support Vehicle	Month	$836	3.5	$2,924
Gator Support Vehicle Pickup and	Each	$79	2	$158

Delivery				
Project Report	Man-hours	$75	175	$13,139
Project Report Review	Man-hours	$85	36	$3,068
Subtotal =				$557,224
Contingency (15% Scope + 15% Bid) =	30%			$167,167
Subtotal =				$724,391
Project Management =	6%			$43,463
Remedial Design =	12%			$86,927
Construction Management =	8%			$57,951
			Total Capital Cost =	**$912,732**

ANNUAL O&M COST				
Item	**Unit**	**Rate**	**Quantity**	**Cost**
Annual Sign Maintenance/Education for 30 Years	Each	$2,000	1	$2,000
			Total Annual O&M Cost =	**$2,000**

PERIODIC COST				
Item	**Unit**	**Rate**	**Quantity**	**Cost**
Land Use Controls from Alternative 2	LS	$100,083	1	$100,083
Five Year Review (Year 5, 10, 15, 20, 25, 30)	Event	$57,802	1	$57,802
			Total Periodic Cost =	**$157,885**

PRESENT VALUE ANALYSIS					
Cost Type	**Year**	**Cost/Year**	**Total Cost/Year**	**Discount Factor (%)**	**Present Value**
Capital Cost	0	$912,732	$912,732	1.000	$912,732
Annual O&M Cost	1 - 30	$2,000	$2,000	20.383	$40,766
Periodic Cost	0	$100,083	$100,083	1.000	$100,083
Periodic Cost	5	$57,802	$57,802	0.924	$53,392
Periodic Cost	10	$57,802	$57,802	0.804	$46,498
Periodic Cost	15	$57,802	$57,802	0.696	$40,203
Periodic Cost	20	$57,802	$57,802	0.587	$33,926
Periodic Cost	25	$57,802	$57,802	0.514	$29,695
Periodic Cost	30	$57,802	$57,802	0.450	$25,991

Total Present Value of Alternative 4 = $1,283,287

APPENDIX B

Interview

DETAILS OF A CONFERENCE WITH WITNESS #32– 12/18/01 BY BLAKE INVESTIGATIVE AGENCY

Witness #32 was in the Air Force Reserves and trained at the MMR from 1963 until 1973. This report was prepared by the Blake Investigative Agency.

At the MMR, the witness trained one weekend per month and for 2 weeks in the summer. From 1967 until 1973, he was an EOD at the MMR. He was trained at the Indian Head EOD facility.

During this time, all EOD disposal was done on the Hesse-Eastern J-Range. Demo-1 and Demo-2 were not in use when he was stationed at the base. The late Frank Terry, who was the EOD for the Air Force Reconnaissance Wing at the base, handled all of the paperwork dealing with munitions disposal.

Munitions disposal on the Hesse-Eastern J-Range was done in a crater approximately halfway down the range. They disposed of mainly 2.75" rocket motors, which were burned, and a few 20mm rounds, which came from bad lots of ammunition. When they were conducting UXO disposal, there was always a fire truck and an ambulance from the Air Force Fire Department present. Outdated pilot survival kit flares were also disposed in this area of the J-Range.

In 1967 or 1968, there was a drought. The drought caused the water level of a pond located behind the base officer's club to drop. This drop in the water level exposed mortar rounds, grenades, and artillery shells that had been disposed into the pond. The witness thought that the disposal into the pond occurred during World War II and that the munitions were disposed because it was easier than returning them to Ammo Supply. EOD pulled out some grenades and 81mm mortars from the pond and disposed of them on the Hesse-Eastern J-Range. This pond was located near the PX and NCO club and these buildings were all constructed of brick at the time.

The witness had no information on the E-Range or contact with the Impact Area. He did not work for any of the base contractors and was not involved with gas training or pyrotechnics. He never policed the artillery or mortar firing positions and had no information on the base landfill. Herbicides and pesticides were not in use at the MMR, during his tenure there. He was selling these products for W.R. Grace and would have known if they were being used at the base.

DETAILS OF A CONFERENCE WITH WITNESS #32– SECOND INTERVIEW 2/6/02 BY BLAKE INVESTIGATIVE AGENCY

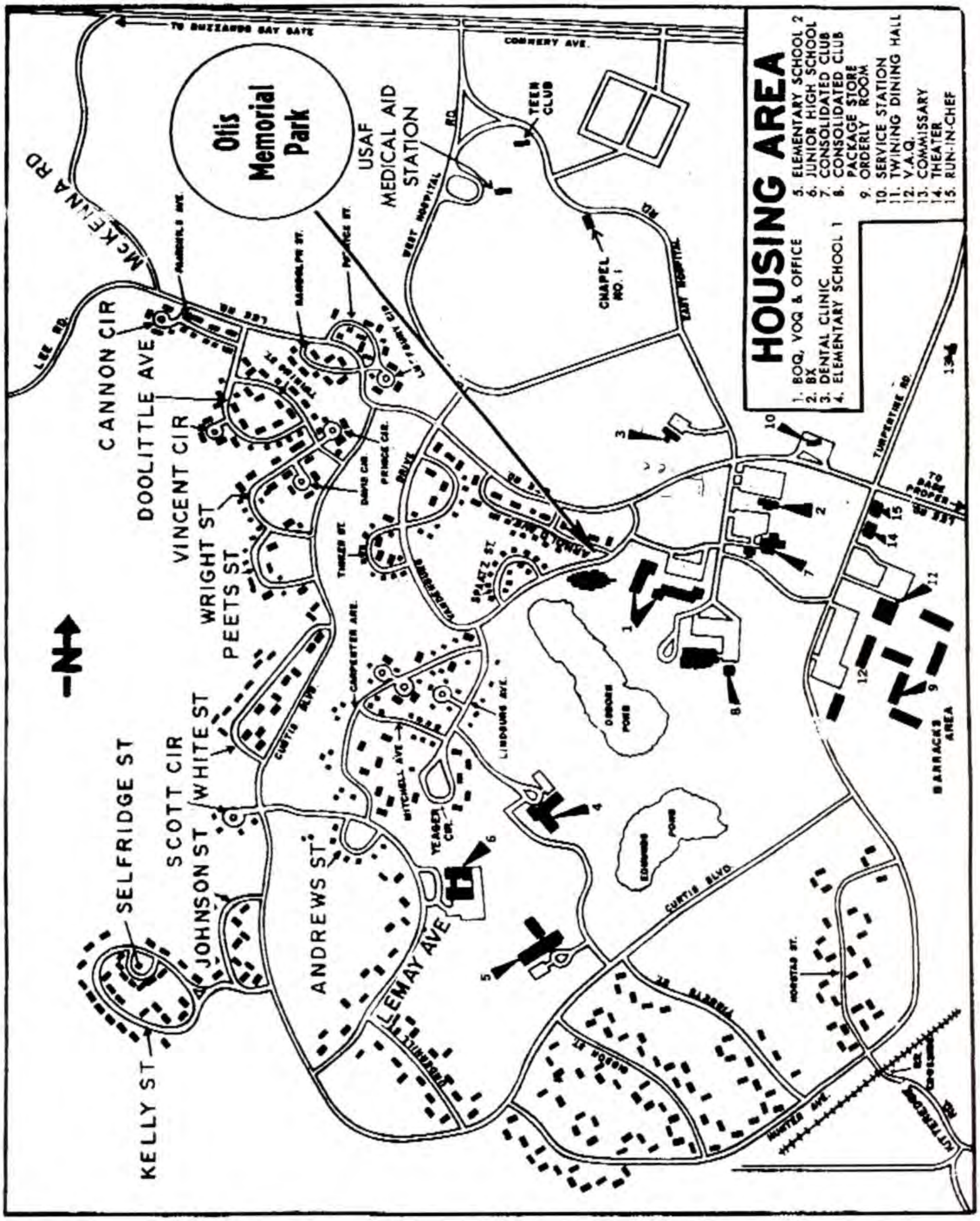
EPA requested additional questions be asked of Witness #32. This report was prepared by the Blake Investigative Agency.

The witness had no recollection of Barlow Road and described the range as a wide open area with no road down the middle of it. Munitions disposal was done in a pit, approximately 100 to 150 yards down range from the trailer which was located at the entrance to the range and served as an office for Hesse-Eastern. The hole or pit was dug with a backhoe, which was operated by the late Frank Terry, an Air Force EOD. The witness did not know who owned the backhoe. The pit was 15 to 20 feet in diameter and 2 to 4 feet deep. It was left open and not covered over after each munitions disposal. There was only one pit and it appeared to have been in use “for years.” The witness recalled that the individuals involved in the munitions disposal were all EOD Air Force personnel.

The witness viewed the map of the area and determined that the location of the munitions was in Osbourne Pond (see attached). The witness did not physically see the munitions, but was aware of the fact through a picture of the pond and the munitions that appeared on the front page of the weekly base newspaper, Otis Notice. The munitions were discovered during a drought, which caused the water level of the pond to drop. The drought occurred during the summer, sometime between 1964 and 1967. The witness did not know whether Edmunds Pond was checked for munitions. At the time, the area was wooded and desolate and the pond was not used for recreational purposes. He believed the newspaper article may have described the area as an old dumping ground from World War II. He thought the munitions were dumped there to avoid the paperwork involved in returning them to Ammo Supply.

The witness thought only the munitions, which were visible, were removed from the pond and did not know if any of the munitions were detonated around the pond.

The witness was not a member of EOD at the time the munitions were discovered and did not participate in their removal.



Witness # 32

#32